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Murakawa et al.

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(45) **Date of Patent: Apr. 19, 2016**

(54) **BODY FAT MEASUREMENT DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 505 days.

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(22) Filed: **Dec. 12, 2012**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2011/066337, filed on Jul. 19, 2011.

(30) **Foreign Application Priority Data**

Jul. 22, 2010 (JP) 2010-165160

(51) **Int. Cl.**
A61B 5/053 (2006.01)
A61B 5/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 5/0537*** (2013.01); ***A61B 5/4872*** (2013.01); ***A61B 5/6823*** (2013.01); *A61B 5/6825* (2013.01); *A61B 5/6829* (2013.01); *A61B 5/6831* (2013.01); *A61B 5/7278* (2013.01)

(58) **Field of Classification Search**
CPC A61B 5/053; A61B 5/0537; A61B 5/4869; A61B 5/4872; A61B 5/6801; A61B 5/6823; A61B 5/6825; A61B 5/6828; A61B 5/6829; A61B 5/6831; A61B 5/6835; A61B 2560/0468; A61B 2562/0209; A61B 2562/046
USPC 600/386, 372, 382, 390, 393, 547, 384
See application file for complete search history.

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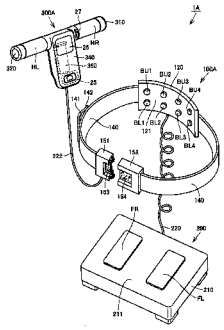
(74) *Attorney, Agent, or Firm* — Osha Liang LLP

(57) **ABSTRACT**

A body fat measurement device includes a plurality of electrodes including back area electrodes and upper limb electrodes, a body impedance measurement unit that measures a body impedance using the plurality of electrodes, a body composition information calculation unit that calculates a body fat mass based on the body impedance, a fitting belt for bringing the back area electrodes into contact with the surface of the measurement subject's back area in a pressurized state, and an upper limb unit that includes a gripping portion that can be gripped by the measurement subject's hand, the upper limb electrodes being provided in the gripping portion. The upper limb unit can be attached to and detached from the fitting belt.

10 Claims, 16 Drawing Sheets



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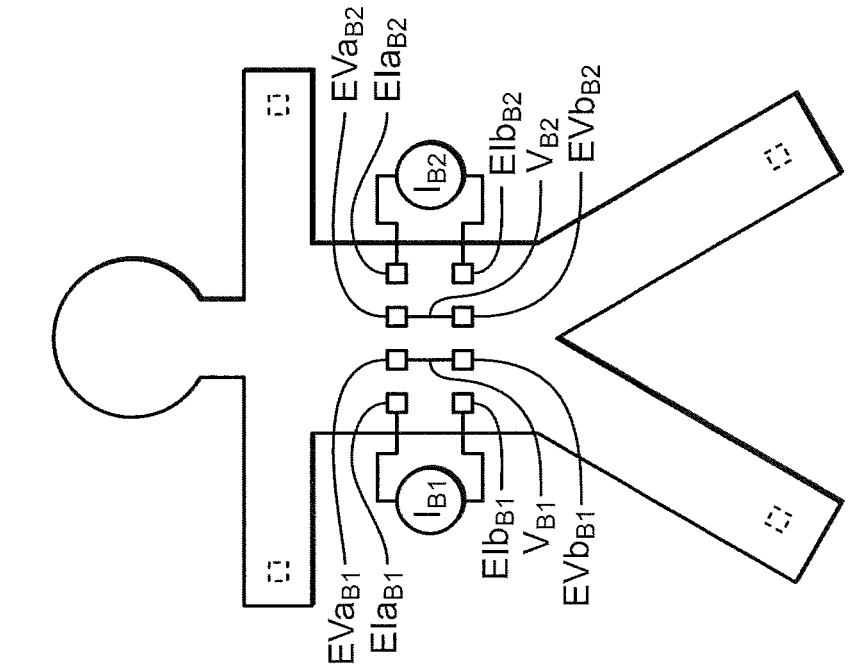
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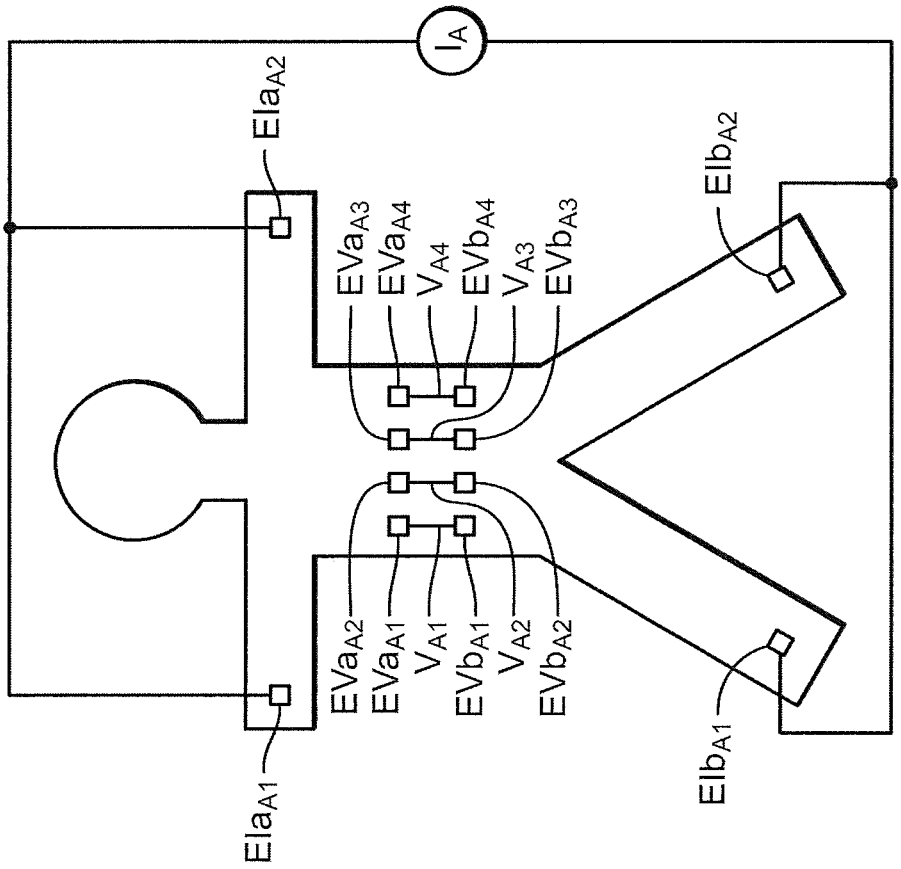
ElaB2
IB2
ElbB2
VB2
EVbB2
EVaB1
ElaB1
IB1
ElbB1
VB1
EVbB1

FIG. 1B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ElaA2
EVaA3
EVaA4
VA4
EVbA4
VA3
EVbA3
ElbA2
EVaA2
EVaA1
VA1
EVbA1
VA2
EVbA2
ElaA1
ElbA1

FIG. 1A

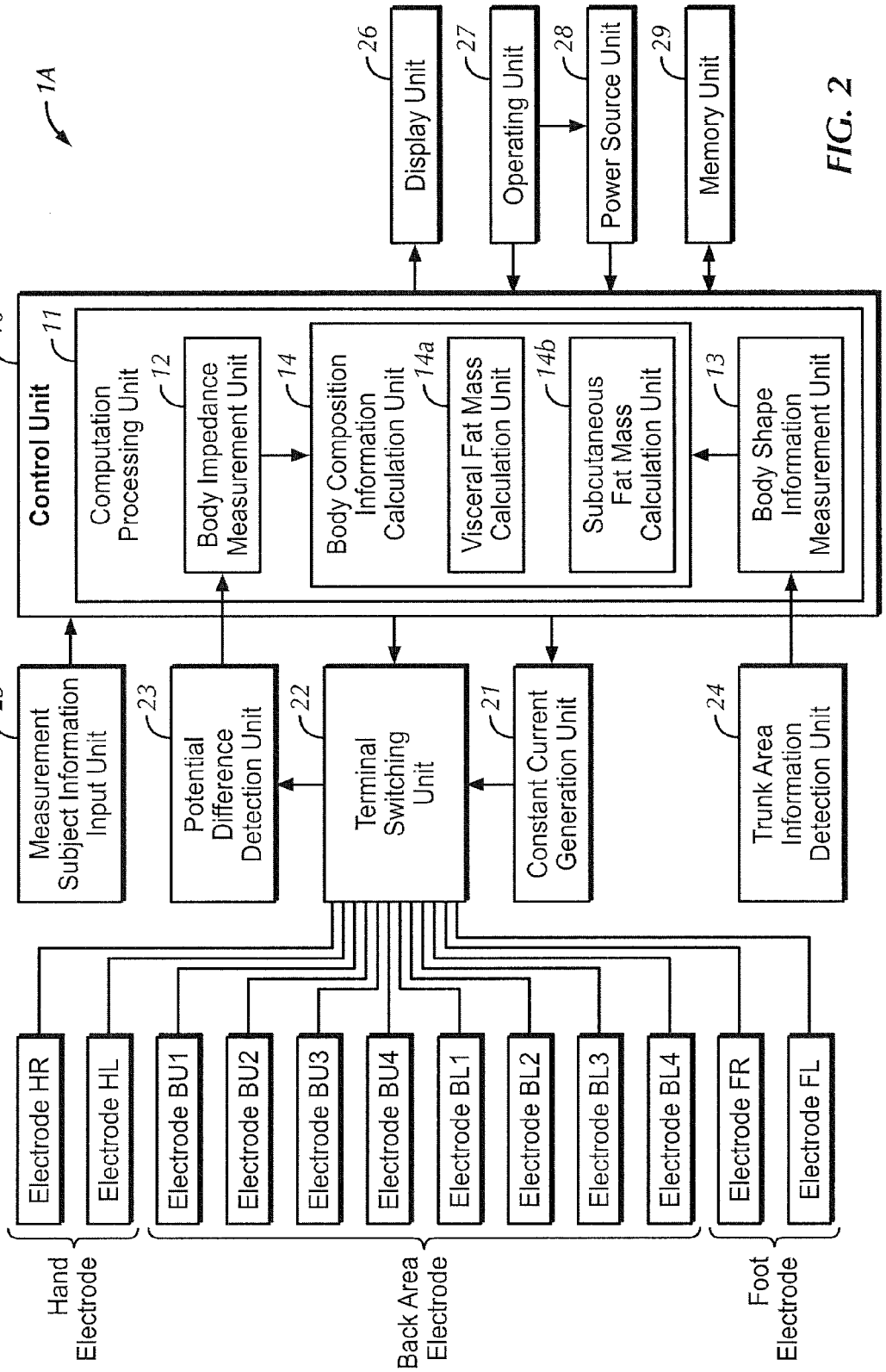
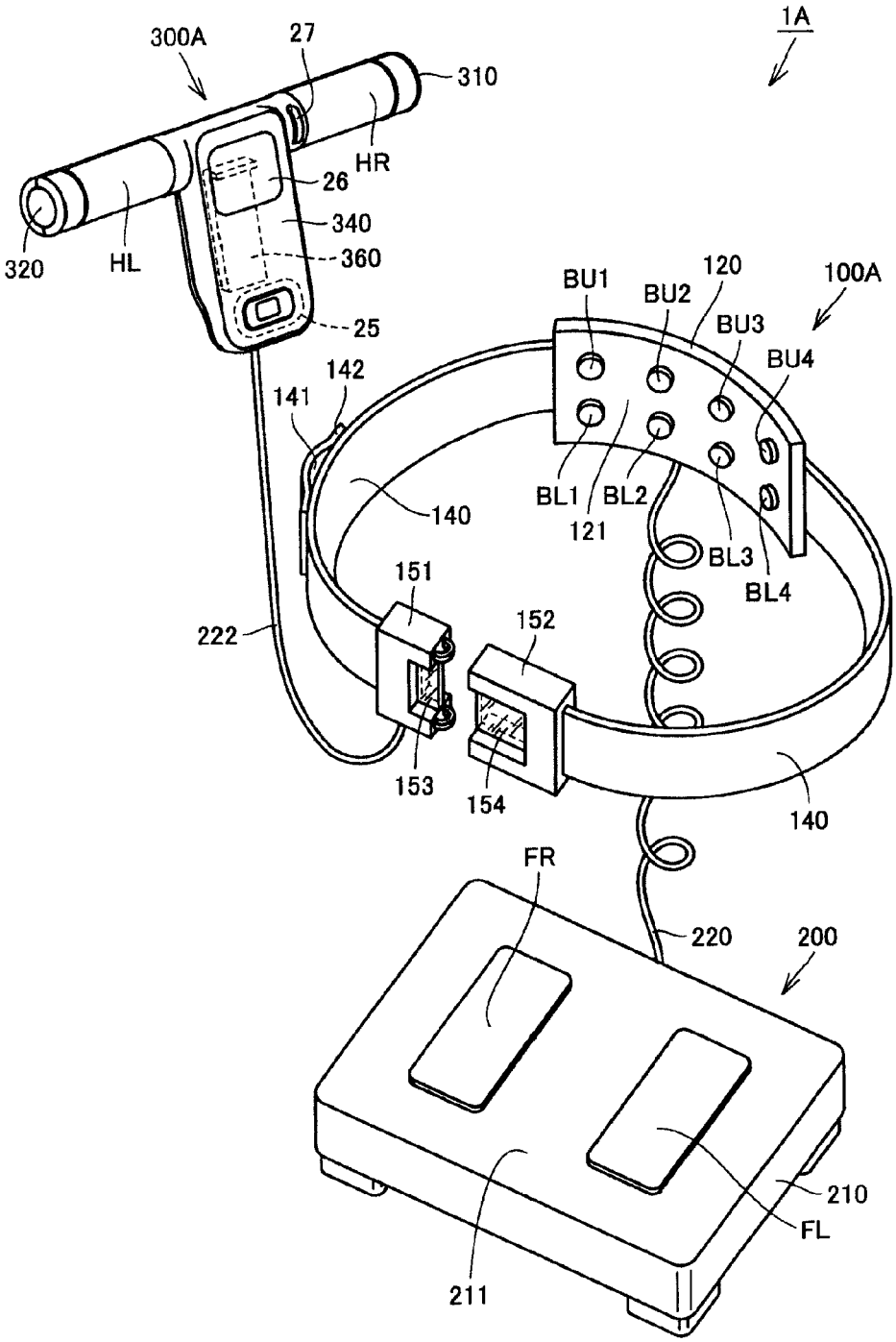

1A
10
Control Unit
11
Computation Processing Unit
12
Body Impedance Measurement Unit
14
Body Composition Information Calculation Unit
14a
Visceral Fat Mass Calculation Unit
14b
Subcutaneous Fat Mass Calculation Unit
13
Body Shape Information Measurement Unit
26
Display Unit
27
Operating Unit
28
Power Source Unit
29
Memory Unit
25
Measurement Subject Information Input Unit
23
Potential Difference Detection Unit
22
Terminal Switching Unit
21
Constant Current Generation Unit
24
Trunk Area Information Detection Unit
Electrode HR
Electrode HL
Electrode BU1
Electrode BU2
Electrode BU3
Electrode BU4
Electrode BL1
Electrode BL2
Electrode BL3
Electrode BL4
Electrode FR
Electrode FL
Hand Electrode
Back Area Electrode
Foot Electrode

FIG. 2

FIG. 3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27
310
HR
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340
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HL
25
142
141
140
BU1
BU2
120
BU3
BU4
100A
BL1
BL2
121
BL3
BL4
151
152
222
153
154
140
FR
220
200
210
FL
211

FIG. 4A

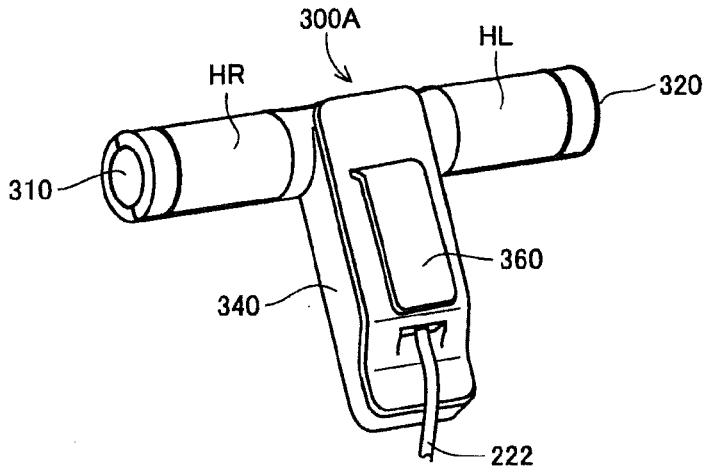
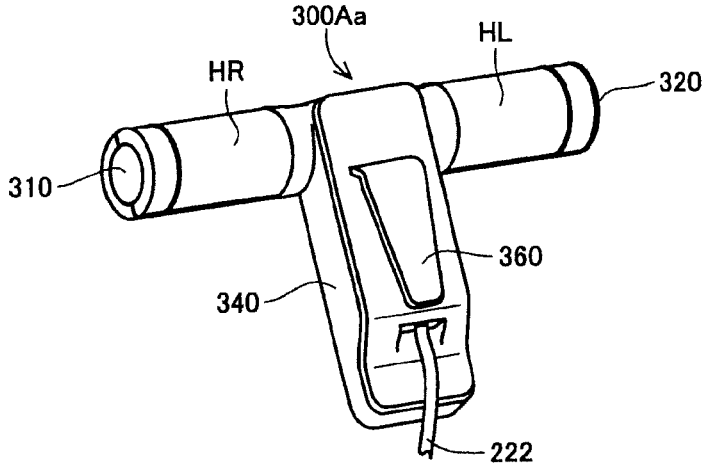


FIG. 4B



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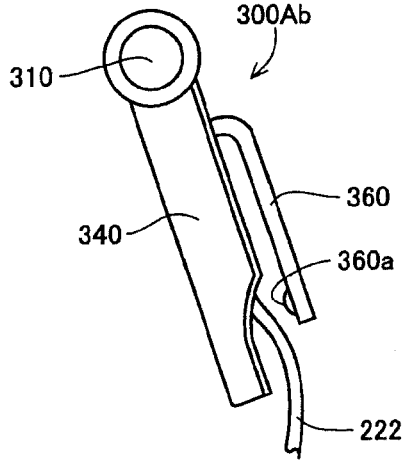
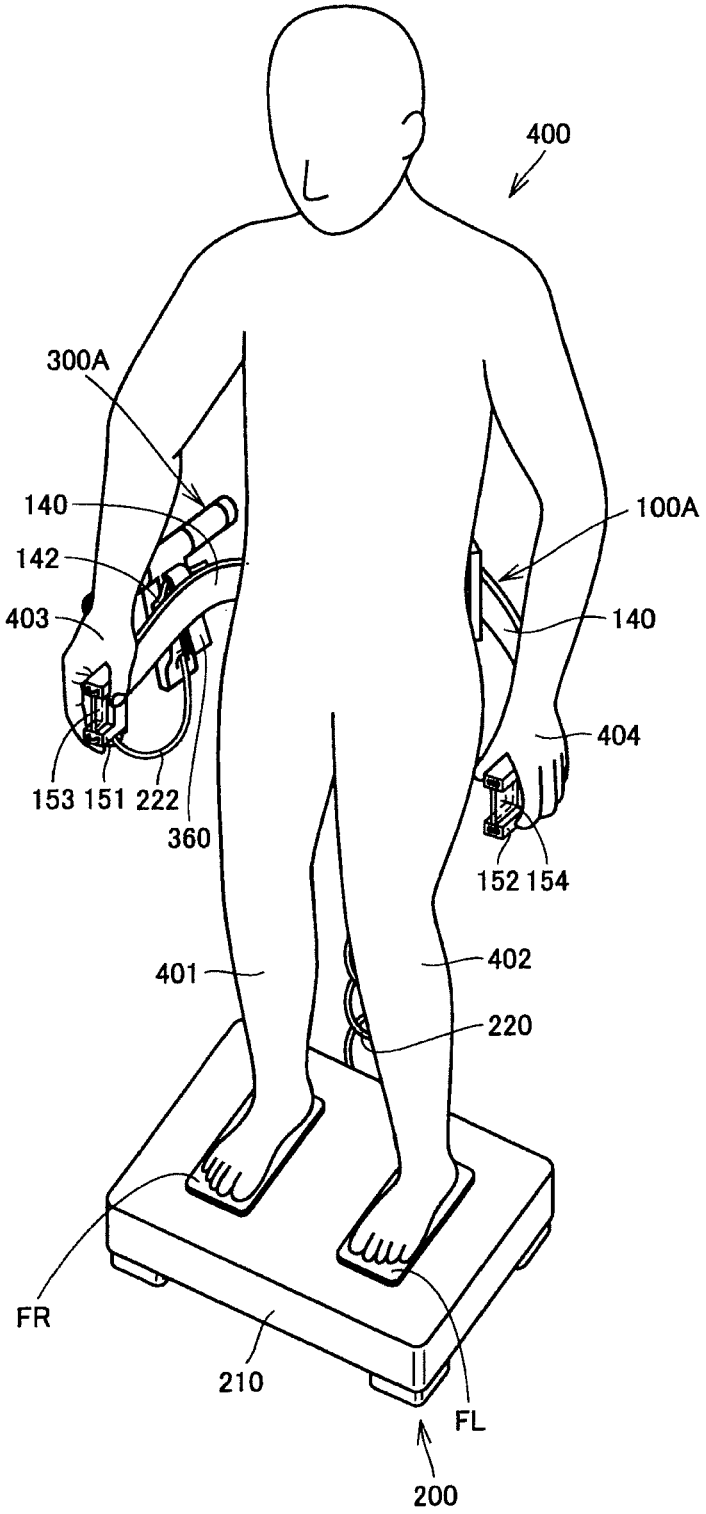


FIG. 5


400
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140
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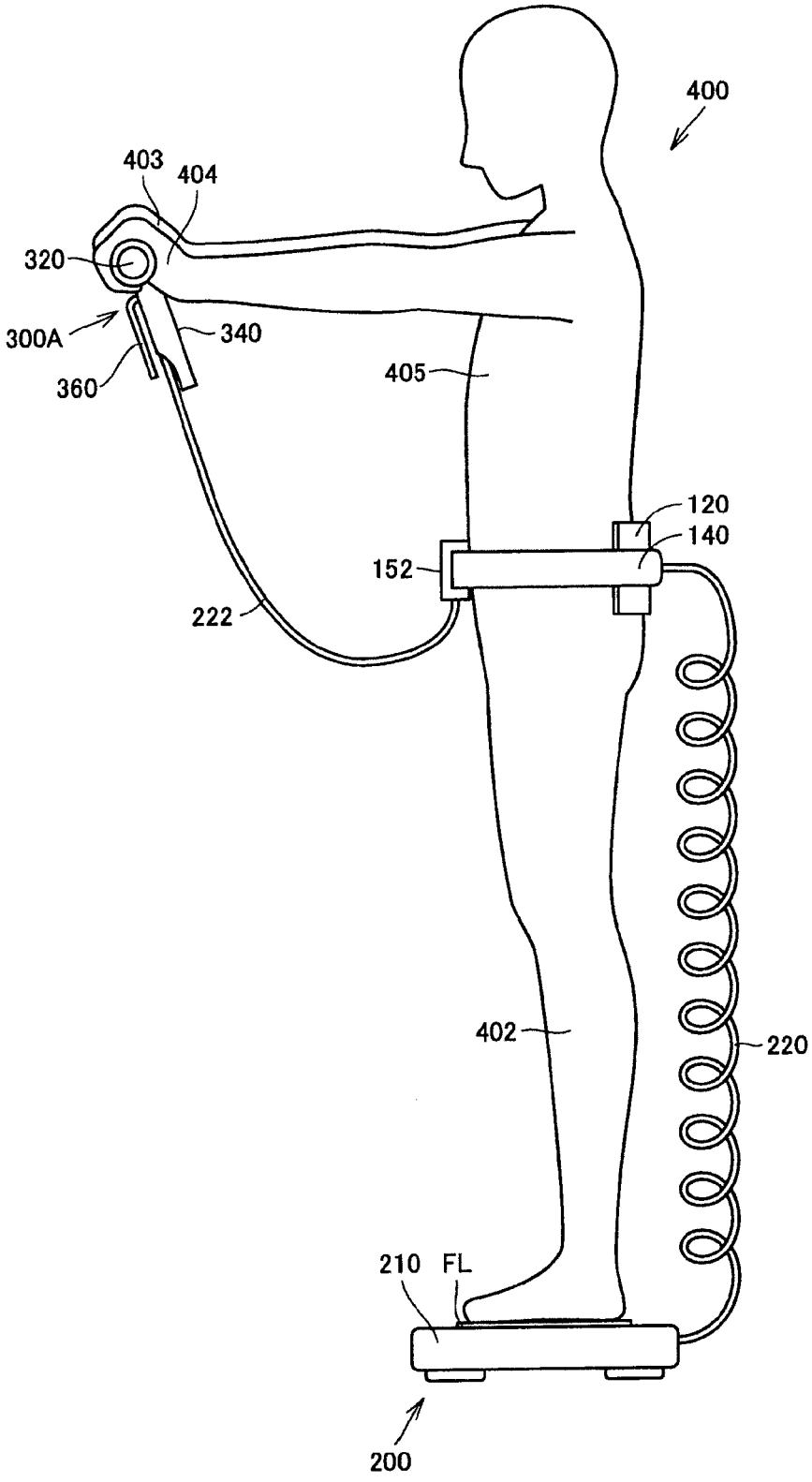
403
153 151 222
360
100A
140
404
152 154
401
402
220
FR
210
FL
200

FIG. 6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403
404
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300A
340
360
405
120
140
152
222
402
220
210
FL
200

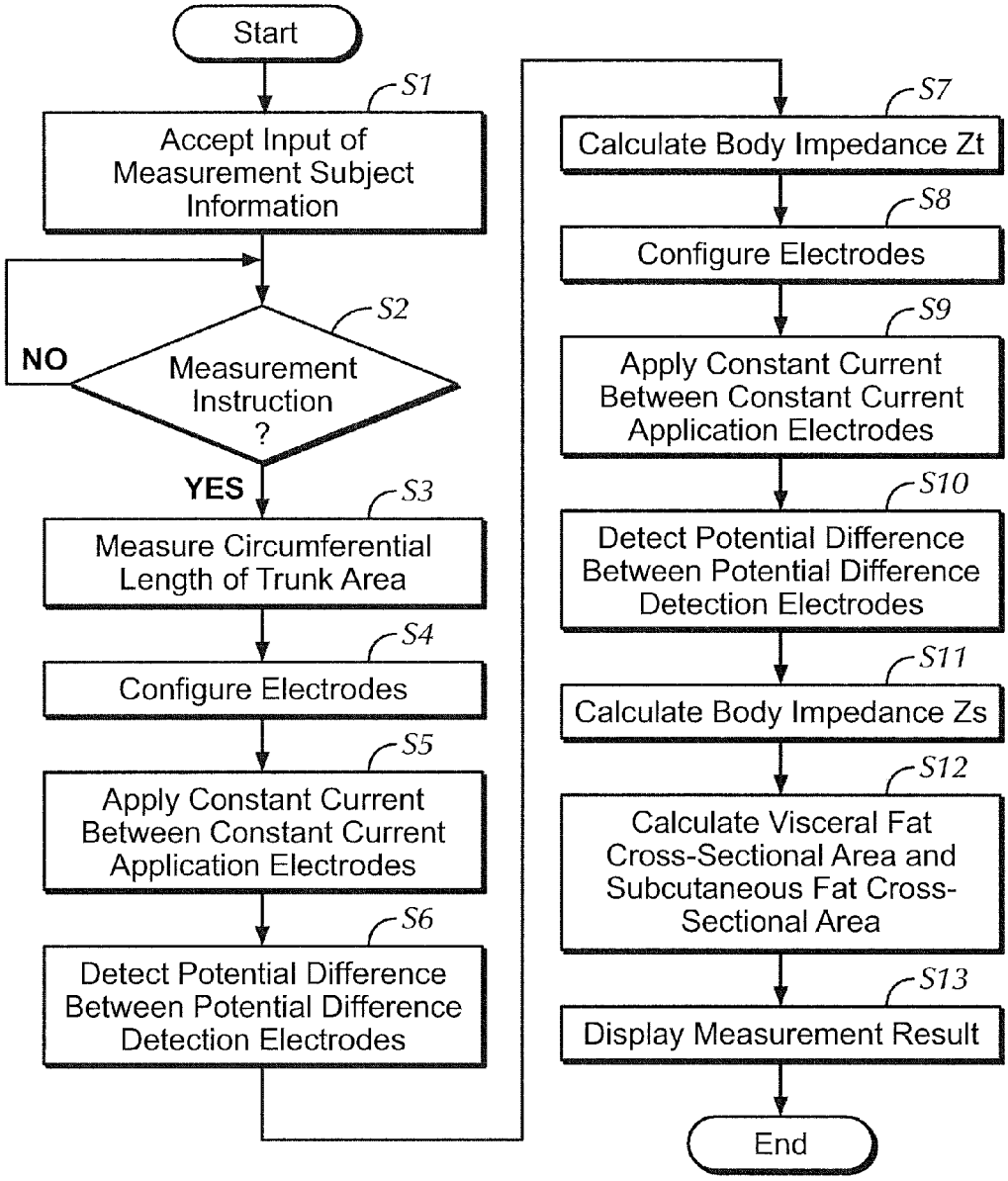
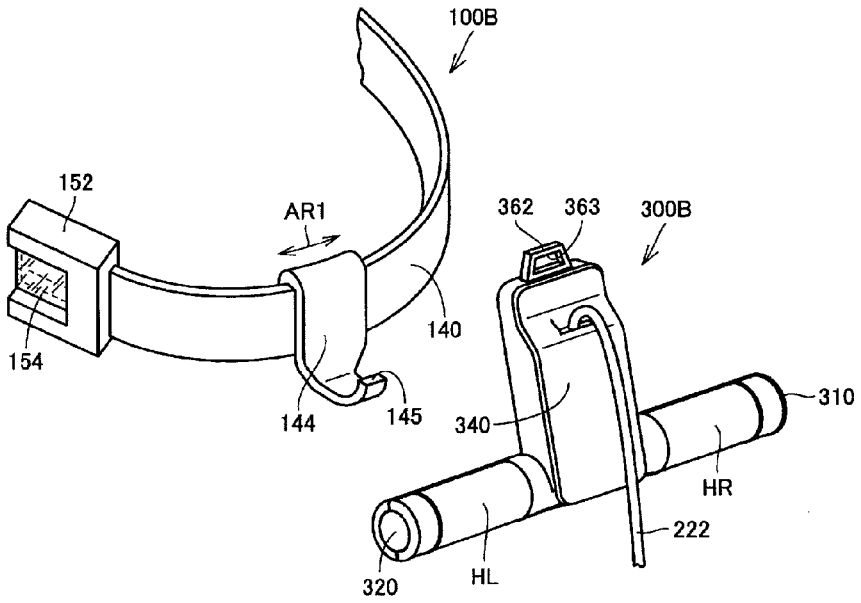

Start
S1
Accept Input of Measurement Subject Information
S2
NO
Measurement Instruction ?
YES
S3
Measure Circumferential Length of Trunk Area
S4
Configure Electrodes
S5
Apply Constant Current Between Constant Current Application Electrodes
S6
Detect Potential Difference Between Potential Difference Detection Electrodes
S7
Calculate Body Impedance Zt
S8
Configure Electrodes
S9
Apply Constant Current Between Constant Current Application Electrodes
S10
Detect Potential Difference Between Potential Difference Detection Electrodes
S11
Calculate Body Impedance Zs
S12
Calculate Visceral Fat Cross-Sectional Area and Subcutaneous Fat Cross-Sectional Area
S13
Display Measurement Result
End

FIG. 7

FIG. 8


100B
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AR1
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300B
140
154
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340
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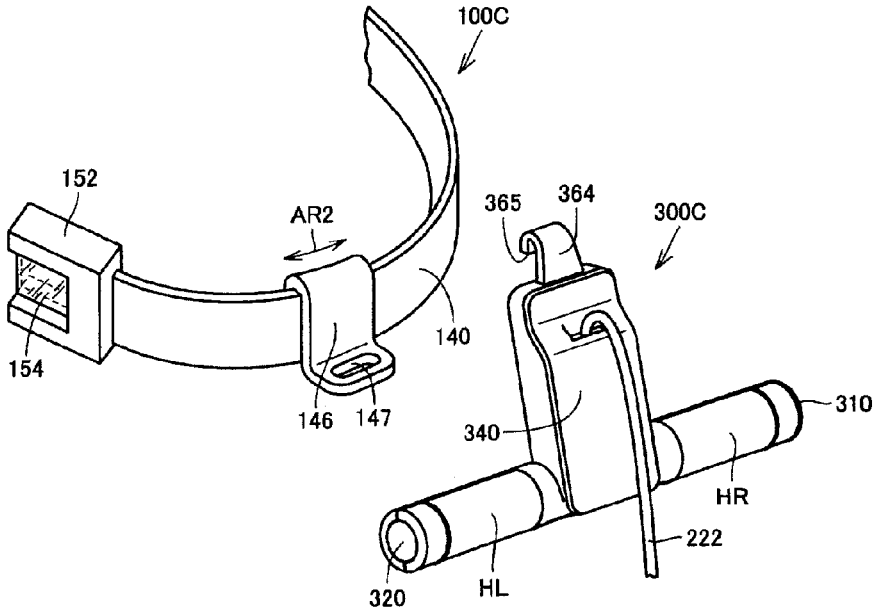
HR
222
320
HL

FIG. 9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300C
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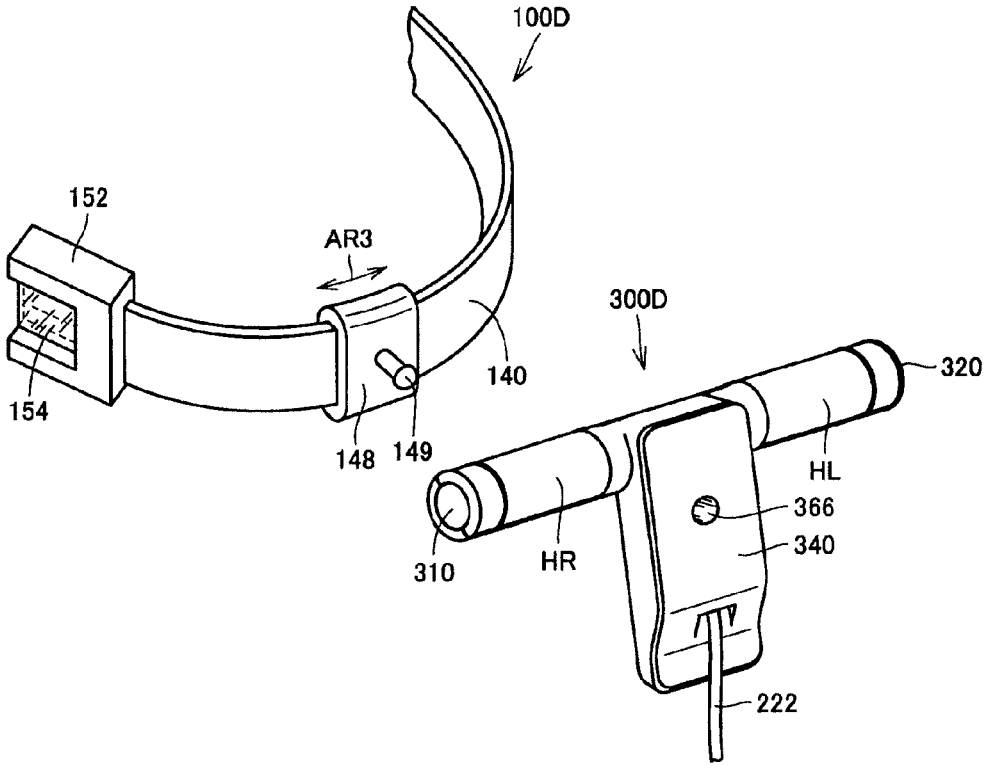
HL

FIG. 10



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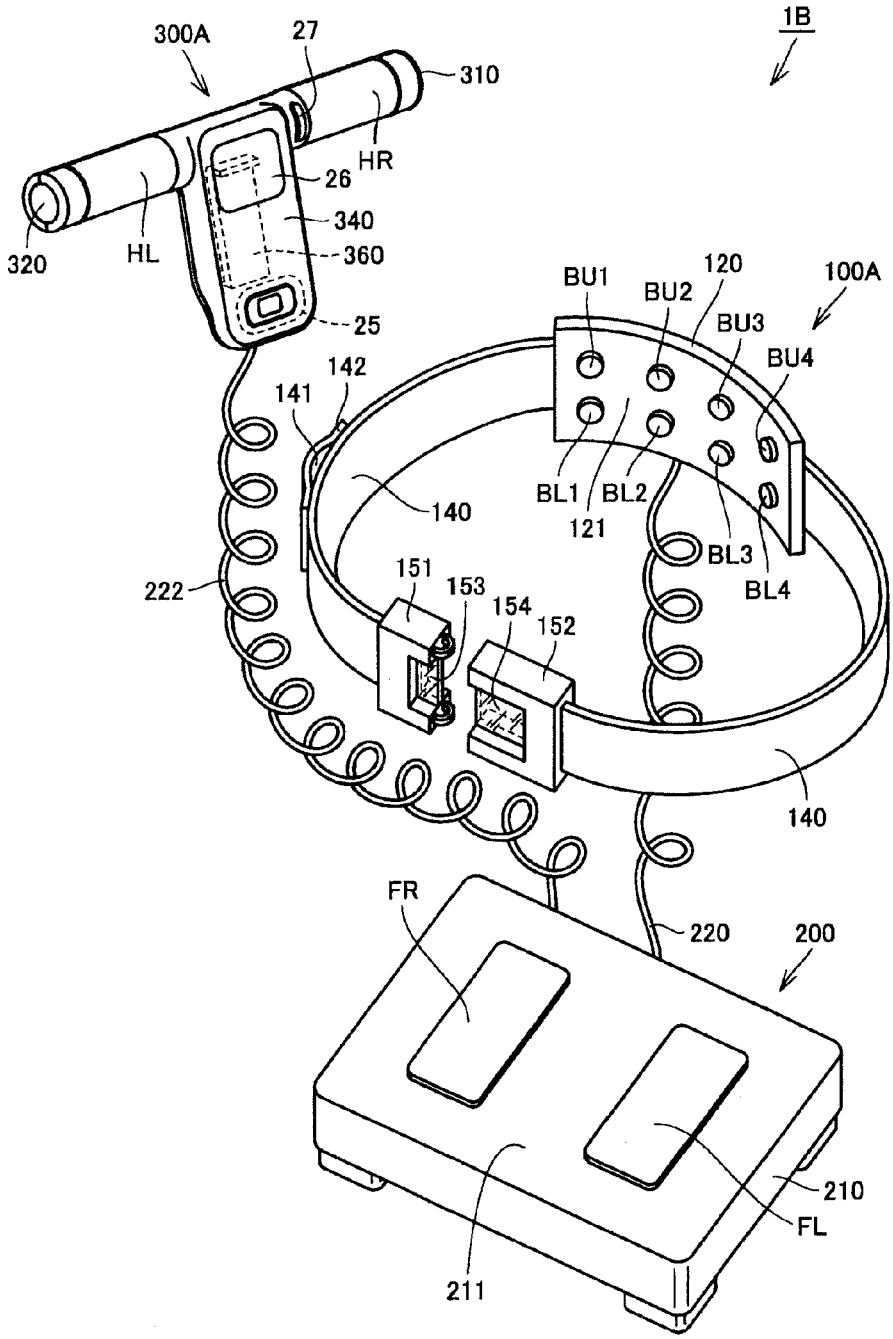
1B
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HR
26
340
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HL
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100A
BU1
BU2
120
BU3
BU4
142
141
140
BL1
BL2
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BL3
BL4
222
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FR
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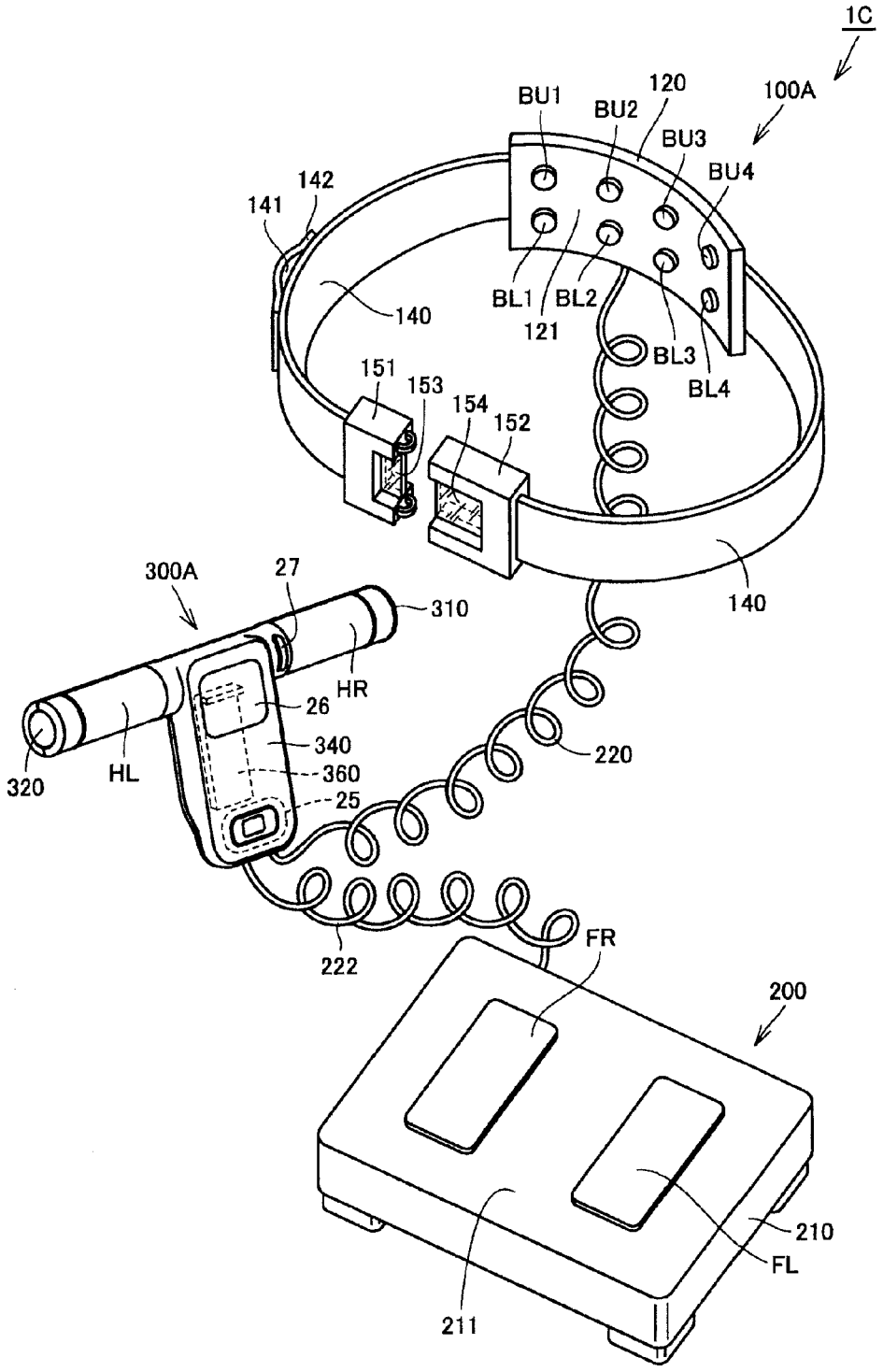
FL
211

FIG. 12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100A
BU1
BU2
120
BU3
BU4
142
141
140
BL1
BL2
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BL3
BL4
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153
154
152
140
300A
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HR
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HL
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FR
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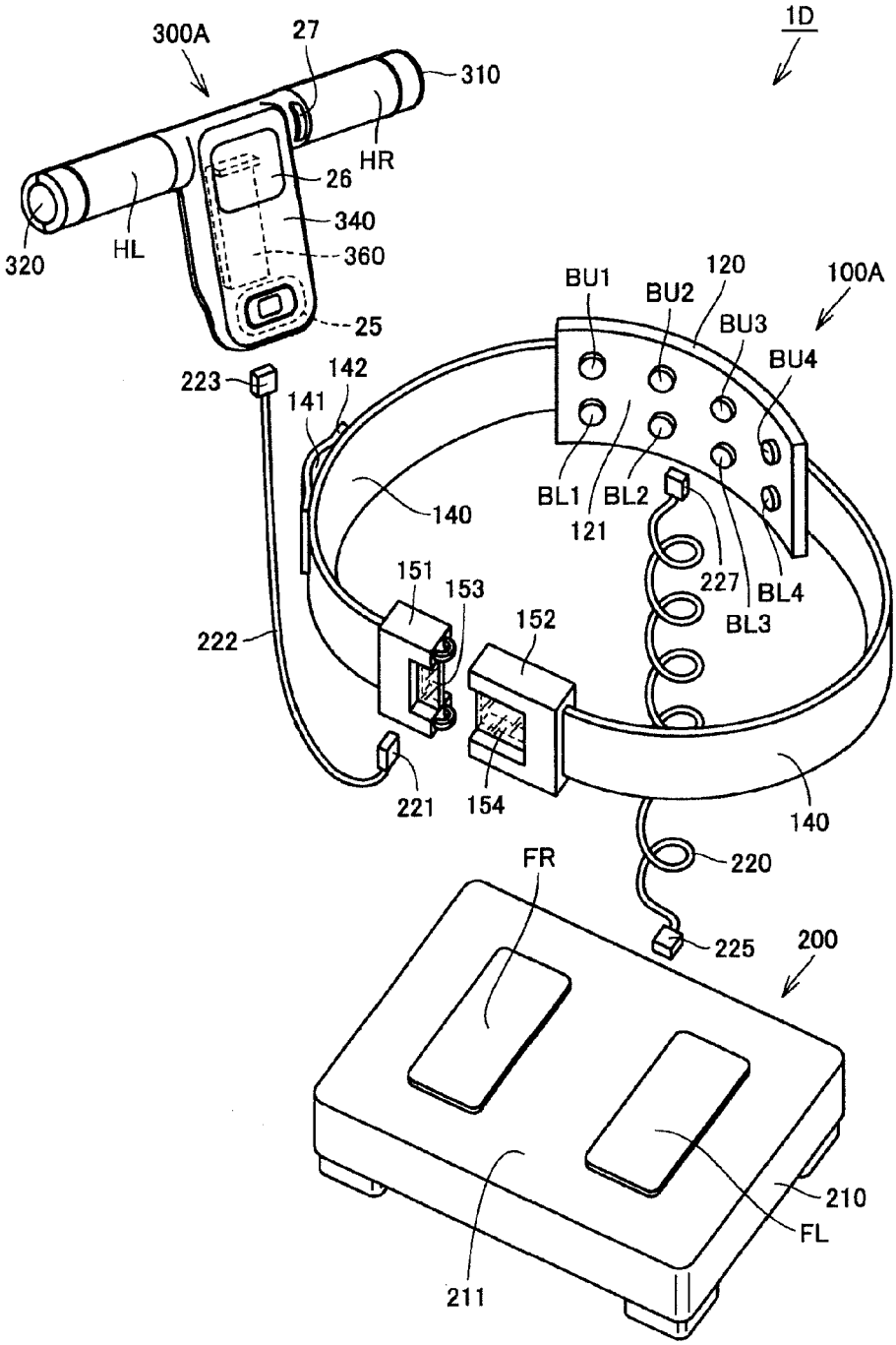
FL
211

FIG. 13


1D
300A
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310
HR
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HL
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223
142
141
140
BU1
BU2
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BU3
100A
BU4
BL1
BL2
121
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BL4
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153
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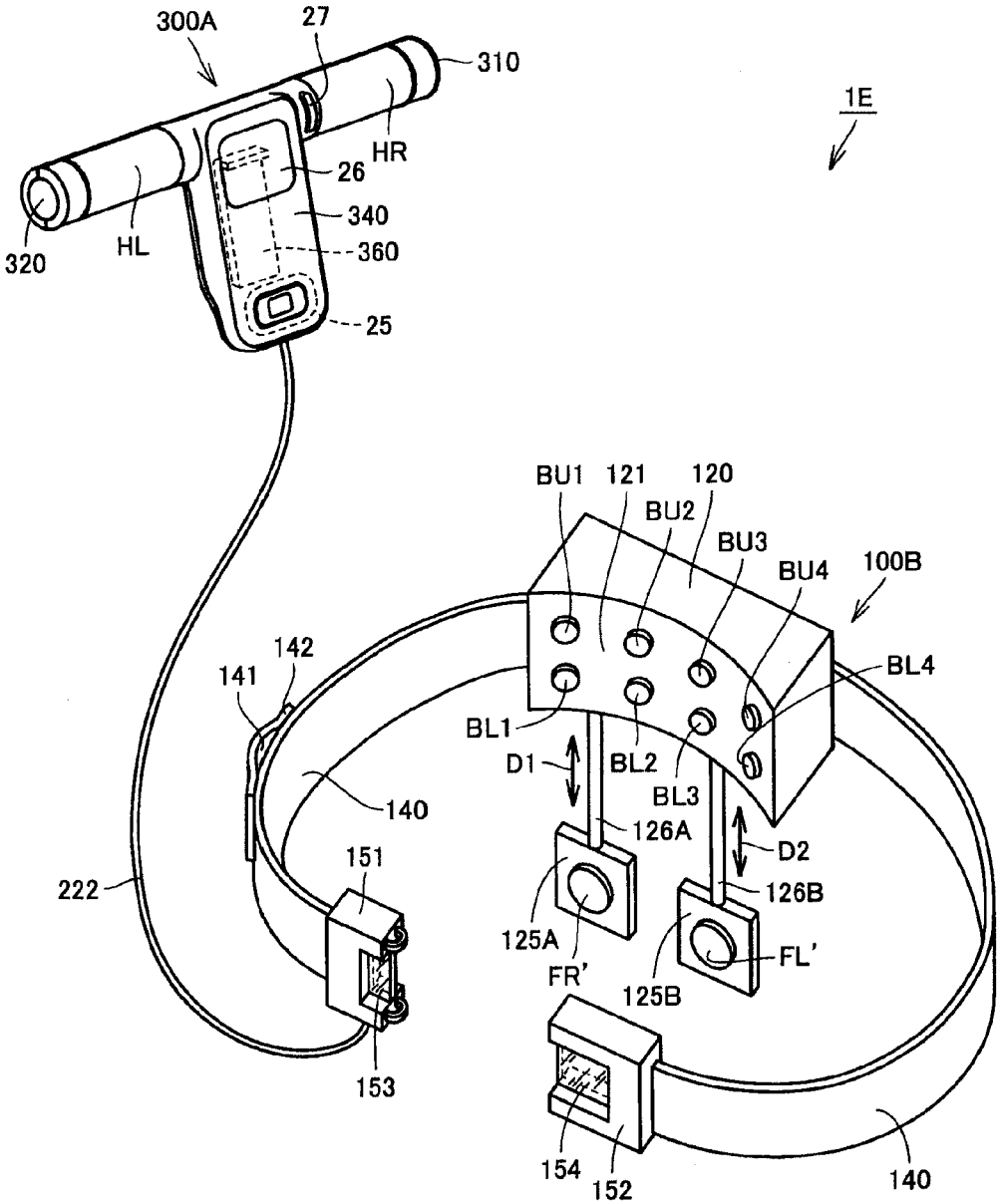
211

FIG. 14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HL
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BU1
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BU2
BU3
BU4
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141
BL4
BL1
D1
BL2
BL3
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D2
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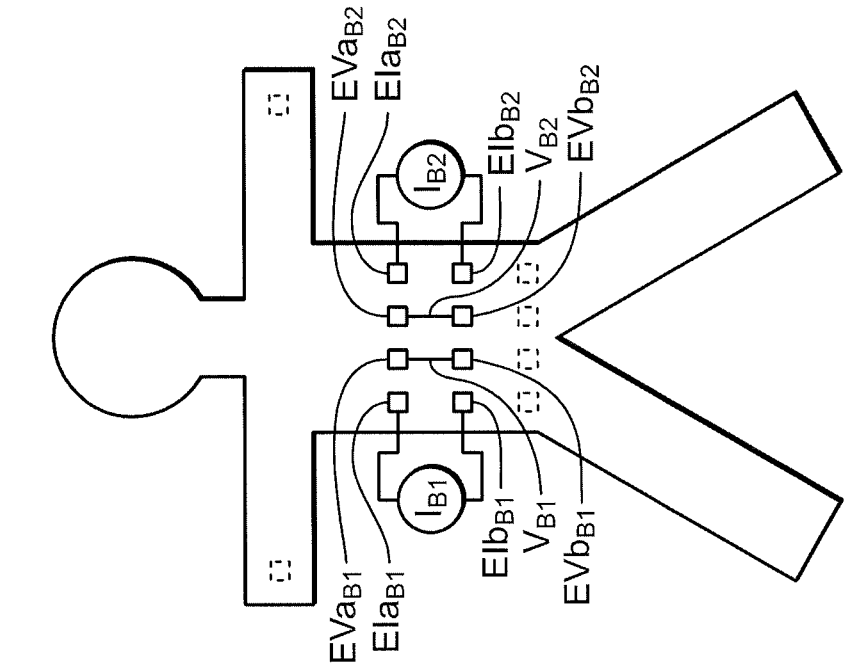
126B
222
125A
FL'
FR'
125B
153
154
152
140



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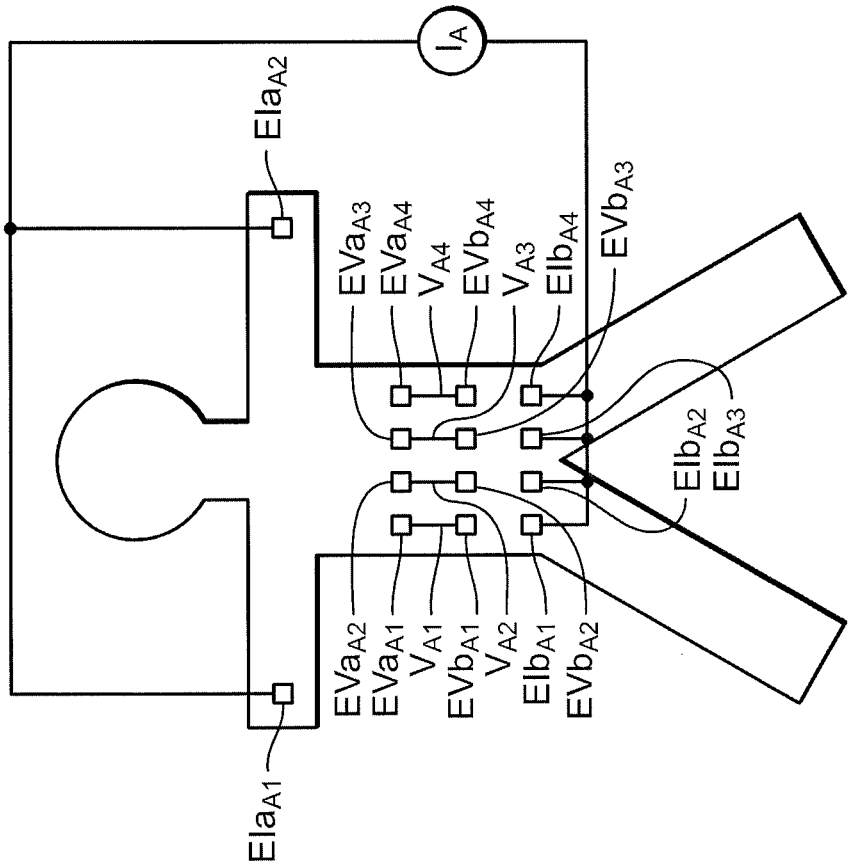
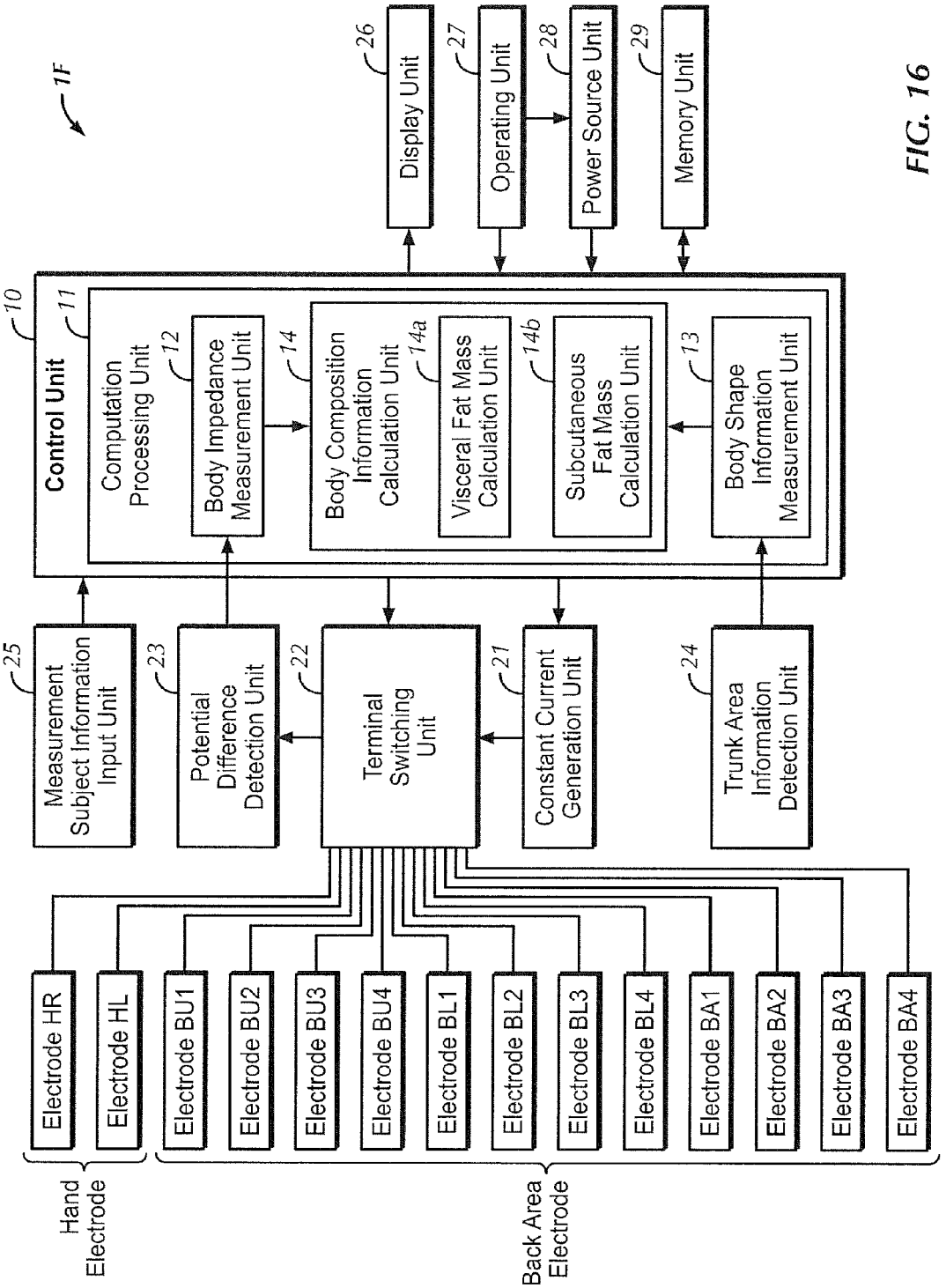


FIG. 15A


1F
Control Unit
10
11
Computation Processing Unit
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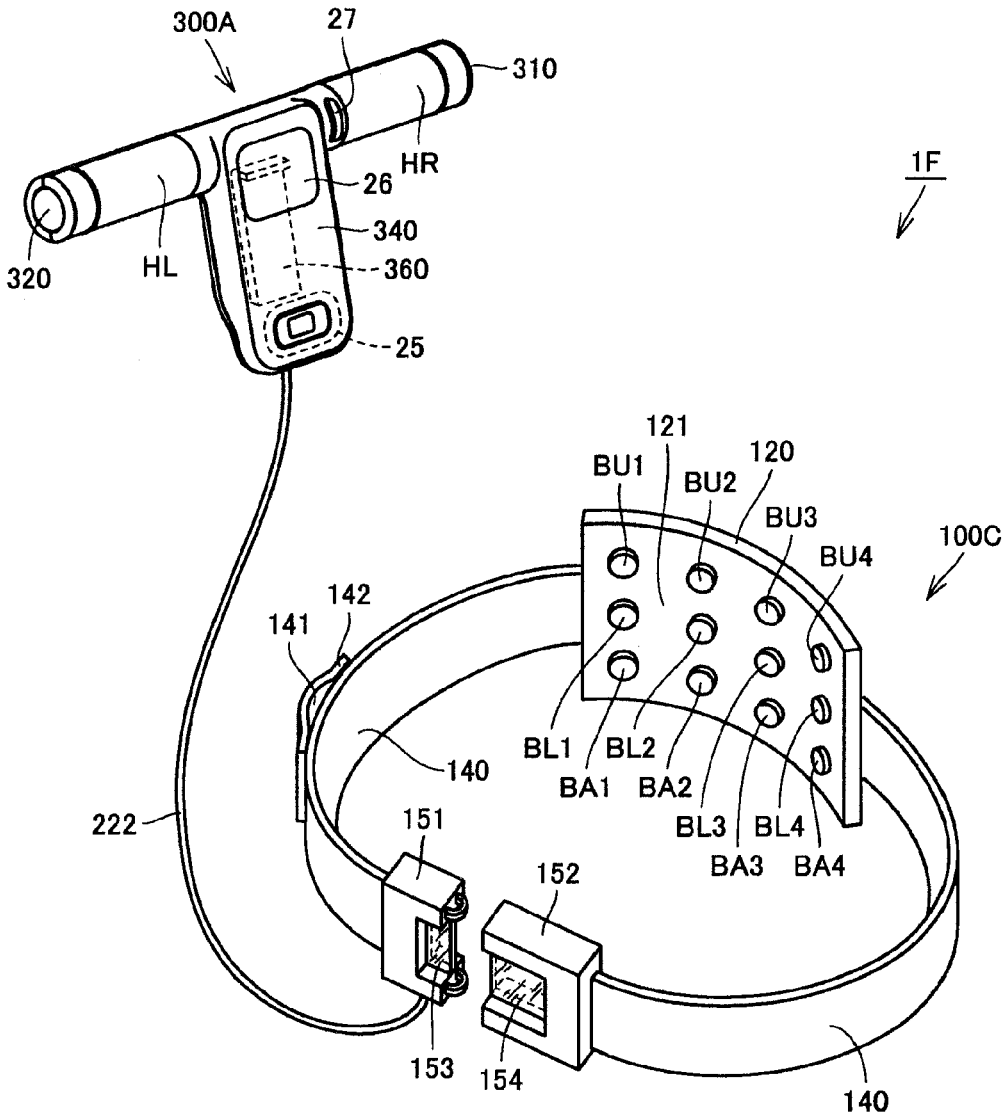
Body Impedance Measurement Unit
14
Body Composition Information Calculation Unit
14a
Visceral Fat Mass Calculation Unit
14b
Subcutaneous Fat Mass Calculation Unit
13
Body Shape Information Measurement Unit
Display Unit
26
Operating Unit
27
Power Source Unit
28
Memory Unit
29
Measurement Subject Information Input Unit
25
Potential Difference Detection Unit
23
Terminal Switching Unit
22
Constant Current Generation Unit
21
Trunk Area Information Detection Unit
24
Electrode HR
Electrode HL
Electrode BU1
Electrode BU2
Electrode BU3
Electrode BU4
Electrode BL1
Electrode BL2
Electrode BL3
Electrode BL4
Electrode BA1
Electrode BA2
Electrode BA3
Electrode BA4
Hand Electrode
Back Area Electrode

FIG. 16

FIG. 17


300A
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BU1
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BU3
BU4
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BL1
BL2
BA1
BA2
222
151
152
BL3
BL4
BA3
BA4
153
154
140

BODY FAT MEASUREMENT DEVICE

TECHNICAL FIELD

The present invention relates to body fat measurement devices configured so as to be capable of calculating the body fat mass of a measurement subject by measuring a body impedance, and particularly relates to body fat measurement devices configured so as to be capable of easily measuring a visceral fat mass and/or a subcutaneous fat mass in households or the like.

BACKGROUND ART

Body fat mass is known as one index used for determining the health of a measurement subject. In particular, a visceral fat mass is known as an index used for determining whether or not a measurement subject suffers from central obesity. Central obesity is said to bring about lifestyle-related diseases that can easily lead to artery hardening, such as diabetes, hypertension, and hyperlipidemia. The aforementioned indexes hold promise in terms of preventing such diseases.

"Visceral fat" refers to fat that builds up in the periphery of the internal organs, and is located on the inner sides of the abdominal muscles and back muscles. Visceral fat is distinguished from subcutaneous fat, which is located in the surface layers of the trunk area. It is typical to employ the area occupied by visceral fat in a cross-section of the trunk area that corresponds to the navel (referred to as a "visceral fat cross-sectional area" hereinafter) as an indicator of the visceral fat mass.

Normally, visceral fat mass is measured by analyzing images obtained through X-ray computed tomography (CT), magnetic resonance imaging (MRI), or the like. In this image analysis, a tomographic image of the trunk area is obtained through the X-ray CT or the like, and the visceral fat cross-sectional area is calculated geometrically from the cross-sectional image.

X-ray CT machines are installed in most medical facilities, and it is difficult to measure a visceral fat mass on a daily basis using the stated image analysis technique. Furthermore, because X-ray CT and the like obtain tomographic images using radiation, it is undesirable to measure the visceral fat mass on a daily basis using X-ray CT and the like.

A body impedance technique is being considered as a method for measuring a body fat mass, as an alternative to image analysis using X-ray CT or the like. In the body impedance technique, electrodes are placed in contact with the four limbs, and a body impedance is measured using those electrodes. The body fat mass is then calculated based on the body impedance.

A body fat measurement device that uses the body impedance technique makes it possible to accurately measure the extent of body fat buildup throughout the entire body or in specific areas such as the four limbs, the trunk area, or the like. However, conventional body fat measurement devices that use the body impedance technique affix electrodes only to the four limbs, as mentioned above. Conventional body fat measurement devices that use the body impedance technique thus cannot make accurate measurements by extracting the extent of visceral fat building, the extent of subcutaneous fat buildup, and so on.

JP 2002-369806A (Patent Literature 1) discloses a technique related to a body fat measurement device. In this body fat measurement device, electrodes are provided on the inner circumferential surface of a belt member. The belt member is affixed to a measurement subject's trunk area, and thus the electrodes are placed in contact with the trunk area.

Meanwhile, JP 2007-014664A (Patent Literature 2) discloses a technique related to a body fat measurement device. In this body fat measurement device, a fitting unit that is fitted onto a measurement subject's trunk area and a lower limb unit onto which the measurement subject steps are configured as separate units. Abdominal area electrodes and handle portions are provided in the fitting unit, and hand electrodes are provided in the handle portions. Foot electrodes are provided in the lower limb unit. By gripping the handle portions with his/her hands, the measurement subject brings the hand electrodes into contact with his/her palms. Then, by pressing the fitting unit against his/her abdominal area using his/her hands that grip the handles, the measurement subject brings the abdominal area electrodes into contact with his/her abdominal area. The measurement subject then brings the foot electrodes into contact with the soles of his/her feet by stepping onto the lower limb unit.

SUMMARY OF INVENTION

In order to realize a body fat measurement device configured to be capable of easily and accurately calculating visceral fat mass and subcutaneous fat mass at home using the body impedance technique, it is extremely important to meet the following two conditions: one, that the measurement can be performed easily through simple operations; and two, that the measurement subject can perform the measurement him/herself without help from an assistant or the like.

However, it is necessary to place electrodes in contact with the measurement subject's back without placing electrodes in contact with the measurement subject's abdominal area and to place electrodes in contact with the hands and feet of the measurement subject in order to calculate the visceral fat mass and the subcutaneous fat mass in a more accurate manner. One of the reasons for this is that the subcutaneous fat that accumulates on the abdominal area side is relatively thinner than the subcutaneous fat that accumulates on the back area side, and thus if the electrodes are placed in contact with the abdominal area, the current that is applied will flow through fat-free areas, which makes it easy for errors to occur.

However, the body fat measurement device disclosed in the stated Patent Literature 1 does not take into consideration placing electrodes in contact with the hands and feet, whereas the body fat measurement device disclosed in the stated Patent Literature 2 does not take into consideration placing electrodes in contact with the back. Thus, it is necessary to make some kind of improvement in order to realize a body fat measurement device capable of easily and accurately calculating a visceral fat mass and a subcutaneous fat mass at home.

Therefore, one or more embodiments of the present invention provide a body fat measurement device capable of easily and accurately measuring body fat masses, such as visceral fat mass, even at home.

A body fat measurement device according to one or more embodiments of the present invention includes: a plurality of electrodes including back area electrodes for making contact with the surface of a back area that is an area on the back side of a measurement subject's trunk area and upper limb electrodes for making contact with the surface of the measurement subject's upper limbs; a body impedance measurement unit that measures a body impedance of the measurement subject's body using the plurality of electrodes; a body composition information calculation unit that calculates a body fat mass based on the body impedance measured by the body

impedance measurement unit; a fitting belt for bringing the back area electrodes into contact with the surface of the measurement subject's back area in a pressurized state by being tightened around the measurement subject's trunk area; and an upper limb unit that includes a gripping portion that can be gripped by the measurement subject's hand, the upper limb electrodes being provided in the gripping portion. Here, the upper limb unit can be attached to and detached from the fitting belt.

A body fat measurement device according to one or more embodiments of the present invention is the body fat measurement device according to the stated first aspect, in which the fitting belt includes a first engagement member; the upper limb unit includes a second engagement member that can engage with the first engagement member; the upper limb unit is attached to the fitting belt by the first engagement member entering an engaged state with the second engagement member; and the upper limb unit can be detached from the fitting belt by canceling the engaged state.

In a body fat measurement device according to one or more embodiments of the present invention, the first engagement member forms an opening by being attached to the fitting belt; the second engagement member has a predetermined length that enables the second engagement member to be inserted into the opening; the upper limb unit is attached to the fitting belt by the second engagement member being inserted into the opening; and the upper limb unit is detached from the fitting belt by the second engagement member being pulled out from the opening.

In a body fat measurement device according to one or more embodiments of the present invention, the position at which the first engagement member is attached to the fitting belt can be moved along the lengthwise direction of the fitting belt.

In a body fat measurement device according to one or more embodiments of the present invention, the upper limb unit includes a display unit that can display body composition information including the body fat mass calculated by the body composition information calculation unit.

In a body fat measurement device according to one or more embodiments of the present invention, the upper limb unit includes an operating unit for accepting an instruction from the measurement subject.

In a body fat measurement device according to one or more embodiments of the present invention, the plurality of electrodes further includes lower limb electrodes for making contact with the surfaces of the measurement subject's lower limbs; and the body fat measurement device further includes a lower limb unit for bringing the lower limb electrodes into contact with the soles of the measurement subject's feet when the measurement subject steps onto the lower limb unit.

In a body fat measurement device according to one or more embodiments of the present invention, the upper limb unit and the fitting belt are electrically connected to each other via a wire; and one of the upper limb unit and the fitting belt is electrically connected to the lower limb unit via a wire.

In a body fat measurement device according to one or more embodiments of the present invention, connection cables that connect the upper limb unit, the fitting belt, and the lower limb unit can be connected to and disconnected from the upper limb unit, the fitting belt, and the lower limb unit.

In a body fat measurement device according to one or more embodiments of the present invention, the lower limb unit includes a body weight measurement unit that measures the weight of the measurement subject.

According to one or more embodiments of the present invention, a body fat measurement device capable of measuring a body fat mass such as a visceral fat mass easily and accurately in a household or the like can be achieved.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1**A is a diagram illustrating fundamentals of measurement performed by a body fat measurement device according to a first embodiment, and illustrates the placement of electrodes when obtaining a body impedance for the entire trunk area; FIG. **1**B is also a diagram illustrating fundamentals of measurement performed by the body fat measurement device according to the first embodiment, and illustrates the placement of electrodes when obtaining a body impedance for a surface layer area on the back area side of the trunk area.

FIG. **2** is a diagram illustrating the functional block configuration of the body fat measurement device according to the first embodiment.

FIG. **3** is a perspective view illustrating the body fat measurement device according to the first embodiment.

FIG. **4**A is a perspective view illustrating an upper limb unit according to the first embodiment from the rear side; FIG. **4**B is a perspective view illustrating another example of the upper limb unit according to the first embodiment from the rear side; and FIG. **4**C is a side view illustrating yet another example of the upper limb unit according to the first embodiment.

FIG. **5** is a diagram illustrating a state prior to a fitting belt of the body fat measurement device according to the first embodiment being fitted on a measurement subject.

FIG. **6** is a diagram illustrating a state after the fitting belt of the body fat measurement device according to the first embodiment has been fitted on a measurement subject.

FIG. **7** is a flowchart illustrating a process performed by a control unit in the body fat measurement device according to the first embodiment.

FIG. **8** is a perspective view illustrating a fitting belt and an upper limb unit according to a first variation on the first embodiment.

FIG. **9** is a perspective view illustrating a fitting belt and an upper limb unit according to a second variation on the first embodiment.

FIG. **10** is a perspective view illustrating a fitting belt and an upper limb unit according to a third variation on the first embodiment.

FIG. **11** is a perspective view illustrating a body fat measurement device according to a second embodiment.

FIG. **12** is a perspective view illustrating a body fat measurement device according to a first variation on the second embodiment.

FIG. **13** is a perspective view illustrating a body fat measurement device according to a second variation on the second embodiment.

FIG. **14** is a perspective view illustrating a body fat measurement device according to a third embodiment.

FIGS. **15**A and **15**B are diagrams illustrating the fundamentals of measurement performed by a body fat measurement device according to a fourth embodiment.

FIG. **16** is a diagram illustrating the functional block configuration of the body fat measurement device according to the fourth embodiment.

FIG. **17** is a perspective view illustrating the body fat measurement device according to the fourth embodiment.

DETAILED DESCRIPTION OF INVENTION

Body fat measurement devices according to one or more embodiments of the present invention will be described in

detail hereinafter with reference to the drawings. When numbers, amounts, and so on are discussed in the following embodiments, unless explicitly mentioned otherwise, the scope of the present invention is not necessarily limited to those numbers, amounts, and so on. In the embodiments, identical and corresponding components may be assigned identical reference numerals, and redundant descriptions thereof may be omitted.

Before describing the various embodiments of the present invention, definitions will be given for terms expressing parts of the body. "Trunk area" refers to the area excluding the head, neck, and four limbs, and corresponds to the trunk of the body. "Back area" refers to the area located on the back side of the stated trunk area, and corresponds to the area of the stated trunk area excluding the abdominal area side and the chest area side. "Back area surface" refers to the entire body surface of the back area, and indicates the surface of the trunk area that can be seen when a measurement subject is observed from the back side. Finally, "body axis" refers to an axis located along the direction in which the trunk area extends, or in other words, an axis extending in a direction approximately perpendicular to a side cross-section of the measurement subject's trunk area.

First Embodiment

Fundamentals of Measurement Performed by Body Fat Measurement Device **1**A

The fundamentals of measurement performed by a body fat measurement device **1**A (see FIG. **3**) according to the present embodiment will be described with reference to FIGS. **1**A and **1**B. FIG. **1**A is a diagram illustrating the placement of electrodes when obtaining a body impedance for the entire trunk area. FIG. **1**B, meanwhile, is a diagram illustrating the placement of electrodes when obtaining a body impedance for a surface layer area on the back area side of the trunk area. FIGS. **1**A and **1**B both illustrate the measurement subject from the back side thereof

As shown in FIG. **1**A, electrodes EIa_{A1} and EIa_{A2} are attached to the surface of the left hand of the measurement subject and the surface of the right hand of the measurement subject, respectively. Likewise, electrodes EIb_{A1} and EIb_{A2} are attached to the surface of the left foot of the measurement subject and the surface of the right foot of the measurement subject, respectively. Four pairs of electrodes are attached to the back area surface of the measurement subject, with each pair disposed so as to follow the body axis direction, and with the four pairs arranged in the widthwise direction of the trunk area. Thus a total of eight electrodes, or electrodes EVa_{A1}, EVb_{A1}, EVa_{A2}, EVb_{A2}, EVa_{A3}, EVb_{A3}, EVa_{A4}, and EVb_{A4}, are attached to the back area surface of the measurement subject.

A constant current I_A that passes through the trunk area is applied to the measurement subject using the electrodes EIa_{A1}, EIa_{A2}, EIb_{A1}, and EIb_{A2}. A potential difference V_{A1} is detected using the electrodes EVa_{A1} and EVb_{A1}, a potential difference V_{A2} is detected using the electrodes EVa_{A2} and EVb_{A2}, a potential difference V_{A3} is detected using the electrodes EVa_{A3} and EVb_{A3}, and a potential difference V_{A4} is detected using the electrodes EVa_{A4} and EVb_{A4}.

A body impedance Zt of the entire trunk area is calculated from the potential differences V_{A1}, V_{A2}, V_{A3}, and V_{A4}. According to one or more embodiments of the present invention, the body impedance Zt is calculated based on the average value of the potential differences V_{A1}, V_{A2}, V_{A3}, and V_{A4}. Doing so makes it possible to reduce the influence of variations in the fat distribution within the trunk area.

The constant current I_A flows between both hands and both feet, which are located at a distance from the trunk area. Almost all of the constant current I_A passes through an area of low electrical resistance (that is, areas aside from fat). The stated body impedance Zt calculated from the potential differences V_{A1}, V_{A2}, V_{A3}, and V_{A4} measured using the constant current I_A is greatly influenced by the amount of non-fat areas (internal organs, muscle, and bone) within the trunk area. Accordingly, the area occupied by non-fat areas (called a "non-fat cross-sectional area" hereinafter) Sa in the cross-section of the trunk area in an area corresponding to the location of the navel can be estimated based on the stated body impedance Zt.

Meanwhile, as shown in FIG. **1**B, four pairs of electrodes are attached to the back area surface of the measurement subject, with each pair disposed so as to follow the body axis direction, and with the four pairs arranged in the widthwise direction of the trunk area. Thus a total of eight electrodes, or electrodes EIa_{B1}, EIb_{B1}, EVa_{B1}, EVb_{B1}, EVa_{B2}, EVb_{B2}, EIa_{B2}, and EIb_{B2}, are attached to the back area surface of the measurement subject.

A constant current I_{B1} that passes through the back area locally is applied to the measurement subject using the electrodes EIa_{B1} and EIb_{B1}, and a constant current I_{B2} that passes through the back area locally is applied to the measurement subject using the electrodes EIa_{B2} and EIb_{B2}. The current values of the constant currents I_{B1} and I_{B2} are set to the same value. While the constant currents I_{B1} and I_{B2} are applied, a potential difference V_{B1} is detected using the electrodes EVa_{B1} and EVb_{B1}, and a potential difference V_{B2} is detected using the electrodes EVa_{B2} and EVb_{B2} attached to the back area surface.

A body impedance Zs of the surface layer area on the back area side of the trunk area is calculated form the potential differences V_{B1} and V_{B2}. According to one or more embodiments of the present invention, the body impedance Zs is calculated based on the average value of the potential differences V_{B1} and V_{B2}. Doing so makes it possible to reduce the influence of variations in the fat distribution and the like in the surface layer area in the back area of the trunk area. Potential differences can also be measured in four locations by switching circuits so that the electrodes to which the current was applied serve as electrodes for detecting the potential differences and the electrodes that were detecting the potential differences serve as electrodes for current application. Doing so makes it possible to further reduce the influence of variations in the subcutaneous fat and so on.

In this state, the constant currents I_{B1} and I_{B2} are applied locally to the back area of the trunk area. Thus, almost all of both the applied constant currents I_{B1} and I_{B2} pass through the surface layer area of the back area. The stated body impedance Zs calculated from the potential differences V_{B1} and V_{B2} measured using the constant currents I_{B1} and I_{B2} is greatly influenced by the subcutaneous fat mass. Accordingly, the subcutaneous fat cross-sectional area (called a "subcutaneous fat cross-sectional area" hereinafter) Sb in the cross-section of the trunk area including the location of the navel can be estimated based on the stated body impedance Zs.

Next, an example of a computation process for calculating a visceral fat mass using the stated body impedances Zt and Zs will be described.

If the overall area of the cross-section of the trunk area at the area corresponding to the location of the navel (called a "trunk area cross-sectional area" hereinafter) is taken as St, a visceral fat cross-sectional area Sx can be calculated through the following Formula (1) using the trunk area cross-sectional area St, the non-fat cross-sectional area Sa, and the subcutaneous fat cross-sectional area Sb.

$$Sx=St-Sa-Sb \qquad \text{Formula (1)}$$

The trunk area cross-sectional area St can be calculated using the circumferential length of the trunk area (the so-called waist length), the width of the trunk area, the depth of the trunk area, and so on. For example, when calculating the trunk area cross-sectional area St from the trunk area circumferential length, when the trunk area circumferential length is taken as t, the trunk area cross-sectional area St can be approximated from the following Formula (2).

$$St=t^2/(4\times\pi) \quad \text{Formula (2)}$$

The trunk area cross-sectional area St approximated through the stated Formula (2) is highly likely to contain a significant degree of error. Thus, according to one or more embodiments of the present invention, a more accurate trunk area cross-sectional area St is found by multiplying that trunk area cross-sectional area St by a coefficient a for reducing error. This coefficient a is obtained, for example, by finding the optimum value for a that fulfills $St'=\alpha\times t^2/(4\times\pi)$, from the relationship between the stated t and a trunk area cross-sectional area St' obtained from a sample of a large number of X-ray CT images.

Accordingly, the stated Formula (2) can approximate with a lower degree of error through the following Formula (3) by using the coefficient a.

$$St=\alpha\times t^2/(4\times\pi) \quad \text{Formula (3)}$$

According to one or more embodiments of the present invention, the coefficient a multiplied for correction as described above is optimized as appropriate in accordance with information such as the measurement subject's sex, age, height, weight, and so on (hereinafter, this information will be referred to collectively as "measurement subject information"). The trunk area cross-sectional area St can be approximated with a higher degree of accuracy by changing the value of the stated coefficient a in accordance with the measurement subject information.

The non-fat cross-sectional area Sa can be calculated based on the body impedance Zt of the entire trunk area. However, the non-fat cross-sectional area Sa cannot be accurately calculated using only the body impedance Zt of the entire trunk area. The non-fat cross-sectional area Sa tends to be proportional to the size of the trunk area, and thus it is necessary to further convert the value obtained from the body impedance Zt in order to calculate the non-fat cross-sectional area Sa. Accordingly, the non-fat cross-sectional area Sa can be expressed through, for example, the following Formula (4).

$$Sa=\beta\times t\times(1/Zt) \quad \text{Formula (4)}$$

The stated t is the value of the trunk area circumferential length, as mentioned above, and is thus a value that is related to the size of the trunk area. The value related to the size of the trunk area is not limited to the stated t, and, for example, the trunk area cross-sectional area St may be used, or the width or depth of the trunk area may be used.

The stated β represents a coefficient for converting the body impedance Zt of the entire trunk area into the non-fat cross-sectional area Sa, and an optimum value can be found, for example, based on a sample of a large number of X-ray CT images, in the same manner as when finding the coefficient α. The optimum value for β that fulfils $Sa'=\beta\times t\times(1/Zt)$ can be found from the relationship between a non-fat cross-sectional area Sa' obtained from a sample of a large number of X-ray CT images, the body impedance Zt of the entire trunk area of the measurement subject imaged by the X-ray CT, and the stated t.

According to one or more embodiments of the present invention, the stated coefficient β is optimized as appropriate in accordance with the measurement subject information, in the same manner as the coefficient a mentioned above. The non-fat cross-sectional area Sa can be approximated with a higher degree of accuracy by changing the value of the stated coefficient β in accordance with the measurement subject information.

The subcutaneous fat cross-sectional area Sb can be calculated based on the body impedance Zs of the surface layer area on the back area side of the trunk area. However, the subcutaneous fat cross-sectional area Sb cannot be accurately calculated using only the body impedance Zs of the surface layer area on the back area side of the trunk area. The subcutaneous fat cross-sectional area Sb tends to be proportional to the size of the trunk area, and thus, it is necessary to further convert the value obtained from the body impedance Zs in order to calculate the subcutaneous fat cross-sectional area Sb. Accordingly, the subcutaneous fat cross-sectional area Sb can be expressed through, for example, the following Formula (5).

$$Sb=\gamma\times t\times Zs \quad \text{Formula (5)}$$

The stated t is the value of the trunk area circumferential length, as mentioned above, and is thus a value that is related to the size of the trunk area. The value related to the size of the trunk area is not limited to the stated t, and, for example, the trunk area cross-sectional area St may be used, or the width or depth of the trunk area may be used.

The stated coefficient γ is a coefficient for converting the body impedance Zs of the surface layer area on the back area side of the trunk area into the subcutaneous fat cross-sectional area Sb, and an optimum value can be found, for example, based on a sample of a large number of X-ray CT images, in the same manner as when finding the coefficient a or the coefficient β. The optimum value for γ that fulfils $Sb'=\gamma\times t\times Zs$ can be found from the relationship between a subcutaneous fat cross-sectional area Sb' obtained from a sample of a large number of X-ray CT images, the body impedance Zs of the surface layer area on the back area side of the trunk area of the measurement subject imaged by the X-ray CT, and the stated t.

According to one or more embodiments of the present invention, the stated coefficient γ is optimized as appropriate in accordance with the measurement subject information, in the same manner as the coefficient α and the coefficient β mentioned above. The subcutaneous fat cross-sectional area Sb can be approximated with a higher degree of accuracy by changing the value of the stated coefficient γ in accordance with the measurement subject information.

As described thus far, in the body fat measurement device according to the present embodiment, the visceral fat cross-sectional area Sx is calculated based on the stated Formula (1) using the trunk area cross-sectional area St, the non-fat cross-sectional area Sa calculated based on the body impedance Zt of the entire trunk area, and the subcutaneous fat cross-sectional area Sb calculated based on the body impedance Zs of the surface layer area on the back area side of the trunk area. The visceral fat cross-sectional area Sx is calculated based on the following Formula (6) by substituting the stated Formula (3) through Formula (5) in the stated Formula (1).

$$Sx=\alpha\times t^2/(4\times\pi)-\beta\times t\times(1/Zt)-\gamma\times t\times Zs \quad \text{Formula (6)}$$

Functional Blocks of Body Fat Measurement Device **1**A

FIG. **2** is a diagram illustrating the functional block configuration of the body fat measurement device **1**A according to the present embodiment. As shown in FIG. **2**, the body fat measurement device **1**A primarily includes a control unit **10**, a constant current generation unit **21**, a terminal switching

unit **22**, a potential difference detection unit **23**, a trunk area information detection unit **24**, a measurement subject information input unit **25**, a display unit **26**, an operating unit **27**, a power source unit **28**, a memory unit **29**, and multiple electrodes HR, HL, BU**1**-BU**4**, BL**1**-BL**4**, FR, FL that are affixed to the measurement subject's body.

The control unit **10** controls a computation processing unit **11**. The computation processing unit **11** includes a body impedance measurement unit **12**, a body shape information measurement unit **13**, and a body composition information calculation unit **14**. The control unit **10** is configured of, for example, a CPU (Central Processing Unit), and controls the body fat measurement device **1**A as a whole. The control unit **10** outputs instructions to the various aforementioned functional blocks, accepts inputs of various types of information from the various functional blocks, performs various types of computation processes based on various types of information, and so on. The various types of computation processes are carried out by the computation processing unit **11**.

The aforementioned multiple electrodes include: hand electrodes HR and HL serving as upper limb electrodes placed in contact with surfaces of the upper limbs of the measurement subject; back area electrodes BU**1**-BU**4** and BL**1**-BL**4** placed in contact with the back area surface of the measurement subject; and foot electrodes FR and FL serving as lower limb electrodes placed in contact with surfaces of the lower limbs of the measurement subject.

The hand electrodes HR and HL are placed in contact with the measurement subject's palms, whereas the foot electrodes FR and FL are placed in contact with the soles of the measurement subject's feet. As shown in FIGS. **1**A and **1**B, the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** are arranged in rows and placed in contact with the back area surface of the measurement subject. The hand electrodes FIR and HL, back area electrodes BU**1**-BU**4** and BL**1**-BL**4**, and foot electrodes FR and FL are all electrically connected to the aforementioned terminal switching unit **22**.

The terminal switching unit **22** is configured of, for example, a relay circuit; based on instructions inputted from the control unit **10**, the terminal switching unit **22** electrically connects specific electrodes selected from the stated multiple electrodes to the constant current generation unit **21** and electrically connects specific electrodes selected from the stated multiple electrodes to the potential difference detection unit **23**. The electrodes electrically connected to the constant current generation unit **21** by the terminal switching unit **22** function as constant current application electrodes, and the electrodes electrically connected to the potential difference detection unit **23** by the terminal switching unit **22** function as potential difference detection electrodes.

By the terminal switching unit **22** operating based on instructions inputted from the control unit **10**, the respective multiple electrodes HR, HL, BU**1**-BU**4**, BL**1**-BL**4**, FR, FL function as the respective electrodes EIa_{A1}, EIa_{A2}, EIb_{A1}, EIb_{A2}, EVa_{A1}, EVb_{A1}, EVa_{A2}, EVb_{A2}, EVa_{A3}, EVb_{A3}, EVa_{A4}, and EVb_{A4} shown in FIG. **1**A and the respective electrodes EIa_{A1}, EIb_{A1}, EVa_{B1}, EVb_{B1}, EIa_{B2}, EIb_{B2}, EVa_{B2}, and EVb_{B2} shown in FIG **1**B.

The constant current generation unit **21** generates a constant current based on an instruction inputted from the control unit **10**. The constant current is supplied to the aforementioned constant current application electrodes through the terminal switching unit **22**. A high-frequency current (for example, 50 kHz, 500 μA) that can be used effectively for measuring body composition information is selected as the constant current. The constant current is applied to the measurement subject through the constant current application electrodes.

The potential difference detection unit **23** detects a potential difference between the electrodes electrically connected to the potential difference detection unit **23** by the terminal switching unit **22** (that is, the potential difference detection electrodes). The detected potential difference is outputted to the control unit **10**. The potential difference between the potential difference detection electrodes is detected in a state in which the constant current is applied to the measurement subject.

The trunk area information detection unit **24** is configured of, for example, an electronic tape or the like, and measures the circumferential length of the measurement subject's trunk area. The trunk area information detection unit **24** outputs a signal based on the value detected to the body shape information measurement unit **13**.

The measurement subject information input unit **25** is configured of, for example, keys and the like that can be depressed by the measurement subject, and obtains the measurement subject information used in computation processes carried out by the computation processing unit **11**. The measurement subject information input unit **25** accepts the input of the measurement subject information, and then outputs the measurement subject information to the control unit **10**.

The measurement subject information input unit **25** is not absolutely necessary in the configuration according to one or more embodiments of the present invention. Whether or not to provide the measurement subject information input unit **25** can be determined based on whether or not it is necessary to use the measurement subject information in the computation processes performed by the computation processing unit **11**. Rather than providing the trunk area information detection unit **24** and taking an actual measurement of the trunk area circumferential length, the configuration can also be such that the circumferential length, depth, width, or the like of the trunk area are inputted through the measurement subject information input unit **25** and computations are carried out by the computation processing unit using that information.

The computation processing unit **11** includes the body impedance measurement unit **12**, the body shape information measurement unit **13**, and the body composition information calculation unit **14**. The body composition information obtainment unit **14** includes a visceral fat mass calculation unit **14***a* and a subcutaneous fat mass calculation unit **14***b*. The body impedance measurement unit **12** calculates the body impedance based on a signal inputted from the potential difference detection unit **23**, and outputs that body impedance to the body composition information obtainment unit **14**. The body shape information measurement unit **13** calculates the circumferential length of the measurement subject's trunk area based on a signal inputted from the trunk area information detection unit **24**, and outputs that information to the body composition information calculation unit **14**.

The body composition information obtainment unit **14** calculates and obtains the body composition information based on the body impedance inputted from the body impedance measurement unit **12**, the circumferential length of the trunk area inputted from the body shape information measurement unit **13**, and in some cases, the measurement subject information inputted from the measurement subject information input unit **25** as well. The visceral fat mass calculation unit **14***a* calculates a visceral fat mass and the subcutaneous fat mass calculation unit **14***b* calculates a subcutaneous fat mass.

The display unit **26** is configured of, for example, an LCD (Liquid Crystal Display) or the like, and displays the body

composition information calculated by the body composition information obtainment unit **14**. The visceral fat mass calculated by the visceral fat mass calculation unit **14***a* and the subcutaneous fat mass calculated by the subcutaneous fat mass calculation unit **14***b* are each displayed in the display unit **26** based on signals outputted from the control unit **10**. With the body fat measurement device **1**A, the visceral fat mass is displayed as, for example, the visceral fat cross-sectional area, and the subcutaneous fat mass is displayed as, for example, the subcutaneous fat cross-sectional area.

The operating unit **27** is configured of, for example, buttons and the like that can be depressed by the measurement subject, and is a unit through which commands are inputted to the body fat measurement device **1**A by the measurement subject. The operating unit **27** includes various types of operation buttons such as a power button, a measure button, and so on. The power source unit **28** is an internal power source such as a battery, an external power source such as an AC outlet, or the like, and supplies electrical power to the control unit **10**.

The memory unit **29** is configured of, for example, a RAM (random access memory) or a ROM (read-only memory), and stores various types of data, programs, and so on related to the body fat measurement device **1**A. The memory unit **29** stores, for example, the measurement subject information, the calculated body composition information, a body composition information measurement program for executing a body composition information measurement process (mentioned later with reference to FIG. **7**), and so on.

Structure of Body Fat Measurement Device **1**A

FIG. **3** is a perspective view illustrating the body fat measurement device **1**A according to the present embodiment. The body fat measurement device **1**A includes a fitting belt **100**A, an upper limb unit **300**A, and a lower limb unit **200**.

The fitting belt **100**A has a band-shaped belt portion **140**, buckle portions **151** and **152** that can engage with each other, and an electrode support member **120**, having a curved plate shape, attached to a rear area of the belt portion **140**. The belt portion **140** is capable of surrounding the measurement subject's trunk area. An electronic tape or the like (not shown), serving as a trunk area information detection unit, is provided in the belt portion **140** along the lengthwise direction thereof.

A band-shaped member **142** serving as a first engagement member is stitched to the outside surface of the belt portion **140**, and an opening **141** is formed as a result of the stitching. The band-shaped member **142** may be attached at any desired position in the lengthwise direction of the belt portion **140**.

The buckle portion **151** is attached to one end of the belt portion **140** (the right hand side), whereas the buckle portion **152** is attached to the other end of the belt portion **140** (the left hand side). According to one or more embodiments of the present invention, the belt portion **140** is configured so that when the buckle portions **151** and **152** are engaged with each other, the length in the lengthwise direction can be adjusted automatically or manually. This adjustment makes it possible to tighten the belt portion **140** around the measurement subject's trunk area after the buckle portions **151** and **152** have been engaged with each other. Using the trunk area information detection unit configured of the electronic tape or the like, the fitting belt **100**A measures the circumferential length of the measurement subject's trunk area after the belt portion **140** has been tightened around the measurement subject's trunk area.

The buckle portion **151** has a light-transmissive window portion **153**, and the buckle portion **152** has a light-transmissive window portion **154**. After the belt portion **140** has been tightened around the measurement subject's trunk area, the area of the measurement subject's navel can be visually confirmed from outside the belt portion **140** through the light-transmissive window portions **153** and **154**. A predetermined marker (not shown) is added to the surface of the light-transmissive window portions **153** and **154**. The belt portion **140** is designed to be tightened on the measurement subject when positioned so that the marker and the location of the measurement subject's navel match.

The electrode support member **120** is configured of a curved plate that is bent so that both ends thereof are positioned forward and the center thereof is positioned rearward. The aforementioned back area electrodes BU**1**-BU**4** and BL**1**-BL**4** are provided so as to be exposed on a front surface **121** of the electrode support member **120**. According to one or more embodiments of the present invention, the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** protrude slightly from the front surface **121** of the electrode support member **120**.

The electrode support member **120** is positioned and attached on the inner surface of the belt portion **140** so that surfaces of the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** that make contact with the back area surface of the measurement subject face forward. By being tightened around the measurement subject's trunk area, the belt portion **140** brings the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** into contact with the back area surface of the measurement subject in a pressurized state.

FIG. **4**A is a perspective view illustrating a rear surface side of the upper limb unit **300**A. As shown in FIGS. **3** and **4**A, the upper limb unit **300**A has an overall T shape, and is configured of a box-shaped main body unit **340**, a right-hand grip portion **310** serving as a gripping portion that is gripped by the measurement subject's right hand, and a left-hand grip portion **320** serving as a gripping portion that is gripped by the measurement subject's left hand.

The hand electrode HR is provided in an exposed state on the right-hand grip portion **310**. The hand electrode HL is provided in an exposed state on the left-hand grip portion **320**. An inverted L-shape hanging member **360** serving as a second engagement member is provided on the rear surface of the main body unit **340** so as to project downward. The hanging member **360** has a plate shape that can be inserted into the aforementioned opening **141**. The shape of the hanging member **360** is, however, not limited to a plate shape, and may be any shape, such as a rod shape, having a predetermined length that enables the hanging member **360** to be inserted into the aforementioned opening **141**.

As another example, in the case where the hanging member **360** is configured in a plate shape, according to one or more embodiments of the present invention, the leading end side of the hanging member **360** (that is, the side that is inserted into the opening **141**) has a tapered shape, as with an upper limb unit **300**Aa shown in FIG. **4**B. The upper limb unit **300**Aa is easy to insert into and remove from the fitting belt **100**A.

As yet another example, in the case where the hanging member **360** is configured in a plate shape, a projection **360***a* may be provided in the leading end side of the hanging member **360** (that is, the side that is inserted into the opening **141**), as with an upper limb unit **300**Ab shown in FIG. **4**C. The projection **360***a* can suppress the upper limb unit **300**Ab from falling when the upper limb unit **300**Ab is attached to the fitting belt **100**A.

The measurement subject information input unit **25**, the display unit **26**, and the operating unit **27** are each provided in respective positions in the front surface side of the main body unit **340** (see FIG. **3**). The display unit **26** displays the body composition information calculated by the body composition information obtainment unit **14** (see FIG. **2**). According to one or more embodiments of the present invention, the oper-

ating unit **27**, which is used for accepting instructions from the measurement subject, is provided so as to include a location that is adjacent to the hand electrode RR, as shown in FIG. **3**. Doing so makes it unnecessary for the measurement subject to move his/her fingers during measurement, which improves the operability.

The lower limb unit **200** is configured of a box-shaped platform portion **210**. The aforementioned foot electrodes FR and FL are respectively provided in predetermined locations of a top surface **211** of the platform portion **210** in an exposed state. The measurement subject can step onto the top surface **211**.

The lower limb unit **200** may include a body weight measurement function. By providing a load cell or the like that serves as a body weight measurement unit for detecting a load on the lower limb unit **200**, the weight of the measurement subject standing on the lower limb unit **200** can be measured by the body weight measurement unit. If the configuration is such that body weight information measured by the body weight measurement unit provided in the lower limb unit **200** is inputted into the control unit **10**, the actual measured body weight of the measurement subject can be used as measurement subject information in the various types of computation processes.

One end of a connection cable **220** is connected to the lower limb unit **200**. The other end of the connection cable **220** is connected to the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** of the fitting belt **100**A.

One end of a connection cable **222** is connected to the upper limb unit **300**A. The other end of the connection cable **222** is connected to the buckle portion **151** of the fitting belt **100**A. The other end of the connection cable **222** is electrically connected to the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** by another connection cable (not shown) installed within the belt portion **140** and extending from the buckle portion **151**. As a result, the upper limb unit **300**A, the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** in the fitting belt **100**A, and the lower limb unit **200** have a hard-wired electrical connection.

The connection cable **220** may be configured so as to be taken up into a reel member (not shown) provided in the lower limb unit **200**. The connection cable **222** may also be configured so as to be taken up into a reel member (not shown) provided in the buckle portion **151**.

The control unit **10**, the constant current generation unit **21**, the terminal switching unit **22**, the potential difference detection unit **23**, the memory unit **29**, and so on shown in FIG. **2** may be provided within the lower limb unit **200**, or may be provided within the upper limb unit **300**A. The measurement subject information input unit **25**, the display unit **26**, and the operating unit **27** may be provided in the lower limb unit **200**.

Fitting of Fitting Belt **100**A onto Measurement Subject

FIG. **5** illustrates a state prior to the fitting belt **100**A being fitted onto the measurement subject. FIG. **6** illustrates a state after the fitting belt **100**A has been fitted onto the measurement subject. A procedure to be carried out by the measurement subject when measuring a body fat mass or the like using the body fat measurement device **1**A will be described with reference to FIG. **5** and FIG. **6**.

As shown in FIG. **5**, a measurement subject **400** first inserts the hanging member **360** of the upper limb unit **300**A into the opening **141** in the fitting belt **100**A. The upper limb unit **300**A is attached to the fitting belt **100**A by inserting the hanging member **360** into the opening **141**.

The measurement subject **400** holds the fitting belt **100**A to which the upper limb unit **300**A is attached and steps onto the lower limb unit **200**. The sole of a right foot **401** makes contact with the foot electrode FR, and the sole of a left foot **402** makes contact with the foot electrode FL.

The measurement subject **400** positions the fitting belt **100**A so that the belt portion **140** surrounds his/her trunk area. The measurement subject **400** then engages the buckle portions **151** and **152** with each other. The measurement subject **400** adjusts the position of the belt portion **140** in the circumferential direction so that the predetermined marker (not shown) provided in the light-transmissive window portions **153** and **154** (see FIG. **3**) matches the position of his/her navel. After engaging the buckle portions **151** and **152** with each other, the measurement subject **400** may step onto the lower limb unit **200** of the body fat measurement device **1**A.

As shown in FIG. **6**, the measurement subject **400** removes the upper limb unit **300**A from the fitting belt **100**A. The measurement subject **400** then presses the power button (not shown) at an appropriate timing. The measurement subject **400** grips the right-hand grip portion **310** (see FIG. **3**) with the right hand **403** and grips the left-hand grip portion **320** (see FIG. **3**) with the left hand **404**. The palm of the right hand **403** makes contact with the hand electrode HR (see FIG. **3**), whereas the palm of the left hand **404** makes contact with the hand electrode HL (see FIG. **3**).

The measurement subject **400** then assumes a position in which the right hand **403** (right arm) and the left hand **404** (left arm) are at an approximately right angle to a trunk area **405**. In the case where the reel member capable of taking up the connection cable **222** is provided in the buckle portion **151**, the connection cable **222** is pulled out from the buckle portion **151** by the upper limb unit **300**A being pulled in the forward direction.

The measurement subject **400** then manipulates the operating unit **27** (see FIG. **3**) with the thumb of the right hand **403**. In the case where the length of the belt portion **140** is adjusted automatically, the length of the belt portion **140** increases/decreases as necessary in response to the operating unit **27** being manipulated. However, in the case where the configuration is such that the length of the belt portion **140** is adjusted manually, according to one or more embodiments of the present invention, the measurement subject increases/decreases the length of the belt portion **140** as necessary at the stage of operations when the measurement subject matches the predetermined marker provided in the light-transmissive window portions **153** and **154** with the location of his/her navel.

After the belt portion **140** has been properly tightened around the measurement subject's trunk area, the trunk area circumferential length of the measurement subject **400** is measured by the trunk area information detection unit such as an electronic tape. However, the trunk area circumferential length may, as described above, be directly inputted by the measurement subject through the measurement subject information input unit **25**.

FIG. **7** is a flowchart illustrating processing performed by the control unit **10** (see FIG. **2**) of the body fat measurement device **1**A. A series of processes executed by the control unit **10** will be described in order with reference to FIG. **2** and FIG. **7**.

These processes are stored in advance in the memory unit **29** as a program. A visceral fat cross-sectional area measurement process, a subcutaneous fat cross-sectional area measurement process, and so on are realized by the control unit **10** when the control unit **10** including the computation processing unit **11** reads out and executes that program.

As shown in FIG. **7**, the control unit **10** first accepts an input of the measurement subject information (step S**1**). The measurement subject information is temporarily saved in, for

example, the memory unit **29**. The control unit **10** then determines whether or not there has been an instruction to start the measurement (step S**2**). The control unit **10** stands by until there has been an instruction to start the measurement (NO in step S**2**), and advances to the next process in the case where an instruction to start the measurement has been detected (YES in step S**2**). The instruction to start the measurement is made by the measurement subject manipulating the operating unit **27**.

The control unit **10** obtains the circumferential length of the measurement subject's trunk area based on a signal inputted from the trunk area information detection unit **24** (step S**3**). The trunk area circumferential length is temporarily saved in the memory unit **29**. The control unit **10** outputs an instruction to the terminal switching unit **22** for switching the electrodes (step S**4**). The terminal switching unit **22** configures the multiple electrodes HR, HL, BU**1**-BU**4**, BL**1**-BL**4**, FR, and FL to the configuration of the electrodes shown in FIG. **1**A.

The control unit **10** outputs an instruction to the constant current generation unit **21** for generating the constant current (step S**5**). The constant current generation unit **21** applies the generated constant current I_A between the constant current application electrodes shown in FIG. **1**A. The control unit **10** outputs an instruction to the potential difference detection unit **23** for detecting a potential difference (step S**6**). The potential difference detection unit **23** detects the potential differences V_{A1}, V_{A2}, V_{A3}, and V_{A4} between the potential difference detection electrodes shown in FIG. **1**A, and outputs the detected potential differences to the body impedance measurement unit **12**.

The control unit **10** calculates the body impedance Zt using the body impedance measurement unit **12**, based on the signal inputted from the potential difference detection unit **23** (step S**7**). The body impedance Zt is temporarily saved in the memory unit **29**. The control unit **10** outputs an instruction to the terminal switching unit **22** for switching the electrodes (step S**8**). The terminal switching unit **22** configures the multiple electrodes HR, HL, BU**1**-BU**4**, BL**1**-BL**4**, FR, and FL to the configuration of the electrodes shown in FIG. **1**B.

The control unit **10** outputs an instruction to the constant current generation unit **21** for generating the constant current (step S**9**). The constant current generation unit **21** applies the generated constant currents I_{B1} and I_{B2} between the constant current application electrodes shown in FIG. **1**B. The control unit **10** outputs an instruction to the potential difference detection unit **23** for detecting a potential difference (step S**10**). The potential difference detection unit **23** detects the potential differences V_{B1} and V_{B2} between the potential difference detection electrodes shown in FIG. **1**B, and outputs the detected potential differences to the body impedance measurement unit **12**. The control unit **10** calculates the body impedance Zs using the body impedance measurement unit **12**, based on the signal inputted from the potential difference detection unit **23** (step S**11**).

The body impedance Zs is temporarily saved in the memory unit **29**. The control unit **10** calculates the visceral fat cross-sectional area Sx as the visceral fat mass using the visceral fat mass calculation unit **14***a* and calculates the subcutaneous fat cross-sectional area Sb as the subcutaneous fat mass using the subcutaneous fat mass calculation unit **14***b*, based on the trunk area circumferential length t detected in step S**3**, the body impedance Zt calculated in step S**7**, and the body impedance Zs calculated in step S**11** (step S**12**). The calculated visceral fat cross-sectional area Sx and subcutaneous fat cross-sectional area Sb are temporarily saved in the memory unit **29**.

The control unit **10** outputs, to the display unit **26**, an instruction to display the visceral fat cross-sectional area Sx and subcutaneous fat cross-sectional area Sb (step S**13**). Based on this, the display unit **26** displays those measurement results. Through this, the body fat measurement device **1**A completes the visceral fat cross-sectional area measurement process and the subcutaneous fat cross-sectional area measurement process. A typical value for the body impedance Zt is approximately 5 Ω, whereas atypical value for the body impedance Zs is approximately 80 Ω.

Actions and Effects

The upper limb unit **300**A can be attached to the fitting belt **100**A using the opening **141** provided in the fitting belt **100**A and the hanging member **360** provided in the upper limb unit **300**A. The measurement subject **400** holds the fitting belt **100**A to which the upper limb unit **300**A is attached and steps onto the lower limb unit **200**. After the measurement subject **400** has fitted the fitting belt **100**A around his/her trunk area, s/he can remove the upper limb unit **300**A from the fitting belt **100**A while remaining in an erect position.

According to the body fat measurement device **1**A, the measurement subject **400** does not need to take actions such as picking up the upper limb unit **300**A by squatting or bending over after fitting the fitting belt **100**A around his/her trunk area. According to the body fat measurement device **1**A, the measurement subject **400** can easily assume a position in preparation for measurement.

Because the measurement subject **400** does not need to squat or the like while wearing the fitting belt **100**A, the fitting belt **100**A does not shift from a desired position. According to the body fat measurement device **1**A, body fat measurement can be easily and accurately carried out.

The back area electrodes BU**1**-BU**4** and BL**1**-BL**4** are provided in an exposed state on a rear area of the fitting belt **100**A. The back area electrodes BU**1**-BU**4** and BL**1**-BL**4** can easily be brought into contact with the back area surface in a pressurized state by the measurement subject **400** wearing the fitting belt **100**A. It is not necessary for the measurement subject to assume a face-up or a face-down position to stabilize that contact. The measurement subject **400** can therefore easily measure body fat or the like at home without help from an assistant or the like.

According to the body fat measurement device **1**A, a body fat mass, such as the visceral fat mass, the subcutaneous fat mass, or the like, can be measured in a state in which the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** are brought into contact with the measurement subject's back area surface. According to the body fat measurement device **1**A, it is possible to apply a current locally to the back area, where the subcutaneous fat is relatively thicker, rather than applying a current locally to the abdominal area, where the subcutaneous fat is relatively thinner, which in turn makes it possible to measure the body fat mass is a more accurate manner.

Therefore, according to the body fat measurement device **1**A, a body fat mass, such as the visceral fat mass and the subcutaneous fat mass, can be measured easily and accurately at home. Using the body fat measurement device **1**A makes it possible to obtain such indicators for health management on a daily basis.

Although the opening **141** is formed by the band-shaped member **142** in the fitting belt **100**A of the body fat measurement device **1**A, an opening may be provided directly in the belt portion **140** instead of providing the band-shaped member **142**. In this case, the hanging member **360** of the upper limb unit **300**A is configured to be insertable into that opening.

Instead of employing the band-shaped member **142** and the hanging member **360**, surface fasteners that can engage with each other can be employed as the first and second engagement members, or magnets that can adhere to each other can be employed as the first and second engagement members.

First Variation on First Embodiment

The present variation will be described with reference to FIG. **8**. Here, only the differences from the body fat measurement device **1**A according to the stated first embodiment will be described. A retaining member **144**, serving as the first engagement member, is attached to the belt portion **140** in a fitting belt **100**B according to the present variation. A hook portion **145** is provided on the leading end of the retaining member **144** so as to point upward. According to one or more embodiments of the present invention, the retaining member **144** is capable of moving freely along the lengthwise direction of the belt portion **140**, as indicated by an arrow AR**1**.

A loop-shaped retained member **362**, serving as the second engagement member, is provided in an upper limb unit **300**B according to the present variation, on the base surface side of the main body unit **340**. The retained member **362** may be provided on the upper surface side of the main body unit **340**. An opening **363** provided in the retained member **362** is capable of engaging with the hook portion **145** of the retaining member **144**. As a result of this engagement, the upper limb unit **300**B is attached to the fitting belt **100**B so as to hang down from the retaining member **144**.

The measurement subject holds the fitting belt **100**B to which the upper limb unit **300**B is attached and steps onto the lower limb unit **200** (see FIG. **5**). After the measurement subject has fitted the fitting belt **100**B around his/her trunk area, s/he can remove the upper limb unit **300**B from the fitting belt **100**B while remaining in an erect position.

In the case where the retaining member **144** is capable of freely moving in the direction indicated by the arrow AR**1**, the position at which the upper limb unit **300**B is attached to the fitting belt **100**B is variable, improving the convenience for the measurement subject. Even with the body fat measurement device that includes the fitting belt **100**B and the upper limb unit **300**B, a body fat mass, such as the visceral fat mass and the subcutaneous fat mass, can be measured easily and accurately.

Second Variation on First Embodiment

The present variation will be described with reference to FIG. **9**. Here, only the differences from the body fat measurement device **1**A according to the stated first embodiment will be described. A retained member **146**, serving as the first engagement member, is attached to the belt portion **140** in a fitting belt **100**C according to the present variation. An opening **147** is provided on the leading end of the retained member **146**. According to one or more embodiments of the present invention, the retained member **146** is capable of moving freely along the lengthwise direction of the belt portion **140**, as indicated by an arrow AR**2**.

A retaining member **364**, serving as the second engagement member, is provided in an upper limb unit **300**C according to the present variation, on the base surface side of the main body unit **340**. The retaining member **364** may be provided on the upper surface side of the main body unit **340**. A hook portion **365** provided in the leading end of the retaining member **364** is capable of engaging with the opening **147** of the retained member **146**. As a result of this engagement, the upper limb unit **300**C is attached to the fitting belt **100**C so as to hang down from the retained member **146**.

The measurement subject holds the fitting belt **100**C to which the upper limb unit **300**C is attached and steps onto the lower limb unit **200** (see FIG. **5**). After the measurement subject has fitted the fitting belt **100**C around his/her trunk area, s/he can remove the upper limb unit **300**C from the fitting belt **100**C while remaining in an erect position.

In the case where the retained member **146** is capable of freely moving in the direction indicated by the arrow AR**2**, the position at which the upper limb unit **300**C is attached to the fitting belt **100**C is variable, improving the convenience for the measurement subject. Even with the body fat measurement device that includes the fitting belt **100**C and the upper limb unit **300**C, a body fat mass, such as the visceral fat mass and the subcutaneous fat mass, can be measured easily and accurately.

Third Variation on First Embodiment

The present variation will be described with reference to FIG. **10**. Here, only the differences from the body fat measurement device **1**A according to the stated first embodiment will be described. A retaining member **148**, serving as the first engagement member, is attached to the belt portion **140** in a fitting belt **100**D according to the present variation. A pin **149** is provided on the surface of the retaining member **148** so as to protrude. According to one or more embodiments of the present invention, the retaining member **148** is capable of moving freely along the lengthwise direction of the belt portion **140**, as indicated by an arrow AR**3**.

An opening **366**, serving as the second engagement member, is formed in an upper limb unit **300**D according to the present variation, on the rear surface side of the main body unit **340**. The pin **149** can engage with the opening **366** by inserting the pin **149** into the opening **366**. As a result of this engagement, the upper limb unit **300**D is attached to the fitting belt **100**D so as to hang down from the retaining member **148**.

The measurement subject holds the fitting belt **100**D to which the upper limb unit **300**D is attached and steps onto the lower limb unit **200** (see FIG. **5**). After the measurement subject has fitted the fitting belt **100**D around his/her trunk area, s/he can remove the upper limb unit **300**D from the fitting belt **100**D while remaining in an erect position.

In the case where the retaining member **148** is capable of freely moving in the direction indicated by the arrow AR**3**, the position at which the upper limb unit **300**D is attached to the fitting belt **100**D is variable, improving the convenience for the measurement subject. Even with the body fat measurement device that includes the fitting belt **100**D and the upper limb unit **300**D, a body fat mass, such as the visceral fat mass and the subcutaneous fat mass, can be measured easily and accurately.

Second Embodiment

A body fat measurement device **1**B according to the present embodiment will be described with reference to FIG. **11**. Here, only the differences from the body fat measurement device **1**A according to the stated first embodiment will be described. In the present embodiment, one end of the connection cable **222** is connected to the upper limb unit **300**A, and the other end of the connection cable **222** is connected to the lower limb unit **200**.

The measurement subject holds the fitting belt **100**A to which the upper limb unit **300**A is attached and steps onto the lower limb unit **200**. After the measurement subject has fitted the fitting belt **100**A around his/her trunk area, s/he can remove the upper limb unit **300**A from the fitting belt **100**A while remaining in an erect position. Even with the body fat measurement device **1**B, a body fat mass, such as the visceral fat mass and the subcutaneous fat mass, can be measured easily and accurately.

The connection cable **222** is not limited to the so-called coiled shape shown in FIG. **11**, and may be configured so as to be taken up into a reel member (not shown) provided in the lower limb unit **200**.

First Variation on Second Embodiment

A body fat measurement device **1**C according to the present variation will be described with reference to FIG. **12**. Here, only the differences from the body fat measurement device **1**B according to the stated second embodiment will be described. In the present variation, one end of the connection cable **220** is connected to the upper limb unit **300**A, and the other end of the connection cable **220** is connected to the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** of the fitting belt **100**A.

The measurement subject holds the fitting belt **100**A to which the upper limb unit **300**A is attached and steps onto the lower limb unit **200**. After the measurement subject has fitted the fitting belt **100**A around his/her trunk area, s/he can remove the upper limb unit **300**A from the fitting belt **100**A while remaining in an erect position. Even with the body fat measurement device **1**C, a body fat mass, such as the visceral fat mass and the subcutaneous fat mass, can be measured easily and accurately.

The connection cable **220** is not limited to the so-called coiled shape shown in FIG. **12**, and may be configured so as to be taken up into a reel member (not shown) provided in the upper limb unit **300**A.

Second Variation on Second Embodiment

A body fat measurement device **1**D according to the present variation will be described with reference to FIG. **13**. Here, only the differences from the body fat measurement device **1**A according to the stated first embodiment will be described. In the present variation, a connector **225** is attached to one end of the connection cable **220**. A connector **227** is attached to the other end of the connection cable **220**. A connector **223** is attached to one end of the connection cable **222**. A connector **221** is attached to the other end of the connection cable **222**.

By using the connectors **221**, **223**, **225**, and **227**, the connections between the connection cables **220** and **222** and the upper limb unit **300**A, the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** in the fitting belt **100**A, the buckle portion **151** in the fitting belt **100**A, and the lower limb unit **200** can be disconnected and reconnected.

For example, as shown in FIG. **13**, an electrical hard-wired connection can be established between one end of the connection cable **220** and the lower limb unit **200** using the connector **225**. Likewise, the other end of the connection cable **220** can be electrically connected to the back area electrodes BU**1**-BU**4** and BL**1**-BL**4** in the upper limb unit **300**A using the connector **227**.

One end of the connection cable **222** can be electrically connected to the upper limb unit **300**A using the connector **223**. The other end of the connection cable **222** can be electrically connected to the buckle portion **151** in the fitting belt **100**A using the connector **221**.

Using the connectors **221**, **223**, **225**, and **227**, the connection cables **220** and **222** may be connected as in the body fat measurement device **1**B according to the aforementioned first variation on the second embodiment (see FIG. **11**), or may be connected as in the body fat measurement device **1**C according to the aforementioned second variation on the second embodiment (see FIG. **12**).

The measurement subject holds the fitting belt **100**A to which the upper limb unit **300**A is attached and steps onto the lower limb unit **200**. After the measurement subject has fitted the fitting belt **100**A around his/her trunk area, s/he can remove the upper limb unit **300**A from the fitting belt **100**A while remaining in an erect position. Even with the body fat measurement device **1**D, a body fat mass, such as the visceral fat mass and the subcutaneous fat mass, can be measured easily and accurately.

Third Embodiment

A body fat measurement device **1**E according to the present embodiment will be described with reference to FIG. **14**. The fundamentals of the measurement performed by the body fat measurement device **1**E and the computation processes executed by the control unit are the same as those of the body fat measurement device **1**A according to the aforementioned first embodiment.

Like the body fat measurement device **1**A according to the aforementioned first embodiment, the body fat measurement device **1**E includes the fitting belt **100**B, which can be disposed so as to surround the measurement subject's trunk area in a fitted state. However, unlike the body fat measurement device **1**A according to the aforementioned first embodiment, the body fat measurement device **1**B does not include a platform-shaped lower limb unit onto which the measurement subject can step; instead, electrode pads **125**A and **125**B, serving as extending unit portions configured so as to be extendable from the fitting belt **100**B, are provided.

The electrode pads **125**A and **125**B have approximate plate shapes, and foot/hip electrodes FL' and FR', serving as lower limb/hip electrodes for making contact with the surface of the respective lower limbs or hips, are provided in an exposed state on the main surfaces of the electrode pads **125**A and **125**B, respectively. The one ends of connection cables **126**A and **126**B are attached to upper areas of the electrode pads **125**A and **125**B, respectively, and the other ends of the connection cables **126**A and **126**B are anchored to reel members (not shown) provided within the electrode support member **120**.

In the fitting belt **100**B, the electrode support member **120** is configured as a block-shaped member in order to make it possible to dispose the stated reel members within the electrode support member **120**, and the electrode support member **120** is attached in approximately the center of the belt portion **140**.

Through this, the electrode pads **125**A and **125**B can be extended downward from the fitting belt **100**B by pulling the connection cables **126**A and **126**B, which serve as connection lines, in the direction of arrows D**1** and D**2** shown in FIG. **14**. By adjusting the extension amount of the connection cables **126**A and **126**B, the electrode pads **125**A and **125**B can be attached at desired locations, such as the lower limbs, the hips, and so on of the measurement subject.

Even with the body fat measurement device **1**E, the same effects as the effects described above in the first embodiment can be achieved. In addition, the measurement can be carried out in a seated position as well as a standing position, which makes it even easier to measure the body fat mass. With the body fat measurement device **1**E, there is no lower limb unit, and thus the device configuration can be simplified and the size of the device can be reduced.

Pads that attach to the measurement subject's body through suction, through an adhesive, or that are attached by being wrapped around the measurement subject's body using some sort of wrapping member can be used as the electrode pads **125**A and **125**B; furthermore, pads that are not particularly attached but are anchored by being sandwiched between the measurement subject's body and a seating surface, a floor surface, or the like can be used as the electrode pads **125**A and **125**B.

Fourth Embodiment

Fundamentals of Measurement Performed by Body Fat Measurement Device **1**F

FIG. **15**A is a diagram illustrating the placement of electrodes when obtaining a body impedance for the entire trunk area, whereas FIG. **15**B is a diagram illustrating the placement of electrodes when obtaining a body impedance for a surface layer area on the back area side of the trunk area. FIGS. **15**A and **15**B both illustrate the measurement subject from the back side thereof. The fundamentals of measurement performed by a body fat measurement device **1**F (see FIG. **17**) according to the present embodiment will be described with reference to FIGS. **15**A and **15**B.

The fundamentals of the measurement performed by the body fat measurement device **1**F are basically the same as the fundamentals of the measurement described in the aforementioned first embodiment (see FIG. **2**). However, the positions in which the electrodes used when obtaining the body impedance of the entire trunk area are placed are different from those in the aforementioned first embodiment. As shown in FIG. **15**A, electrodes EIa_{A1} and EIa_{A2} are attached to the surface of the left hand of the measurement subject and the surface of the right hand of the measurement subject, respectively, in order to obtain the body impedance for the entire trunk area.

Four pairs of electrodes are attached to the back area surface of the measurement subject, with each pair disposed so as to follow the body axis direction, and with the four pairs arranged in the widthwise direction of the trunk area; furthermore, four electrodes are attached to an area of the back area surface that is closer to the hip area than the contact locations where the stated four pairs of electrodes are placed, with these four electrodes being arranged along the widthwise direction of the trunk area. In other words, as shown in FIG. **15**A, a total of twelve electrodes, or electrodes EVa_{A1}, EVb_{A1}, EVa_{A2}, EVb_{A2}, EVa_{A3}, EVb_{A3}, EVa_{A4}, EVb_{A4}, EIb_{A1}, EIb_{A2}, EIb_{A3}, and EIb_{A4}, are attached to the back area surface of the measurement subject.

In this state, a constant current I_A that passes through the trunk area is applied to the measurement subject using the electrodes EIa_{A1}, EIa_{A2}, EIb_{A2}, EIb_{A2}, EIb_{A3}, and EIb_{A1}. While the constant current I_A is being applied, the potential difference V_{A1} is detected using the electrodes EVa_{A1} and EVb_{A1}, the potential difference V_{A2} is detected using the electrodes EVa_{A2} and EVb_{A2}, the potential difference V_{A3} is detected using the electrodes EVa_{A3} and EVb_{A3}, and the potential difference V_{A4} is detected using the electrodes EVa_{A4} and EVb_{A4}.

A body impedance Zt of the entire trunk area is calculated from the potential differences V_{A1}, V_{A2}, V_{A3}, and V_{A4}. Note that the placement of electrodes, the constant current application, and the potential difference detection for obtaining the body impedance Zs of the surface layer area on the back area of the trunk area are, as shown in FIG. **15**B, all the same as those in the aforementioned first embodiment.

Functional Blocks of Body Fat Measurement Device **1**F

FIG. **16** is a diagram illustrating the functional block configuration of the body fat measurement device **1**F according to the present embodiment. The functional block configuration of the body fat measurement device **1**F will be described with reference to FIG. **16**.

The body fat measurement device **1**F has a similar configuration as the body fat measurement device **1**A according to the aforementioned first embodiment, but differs slightly in terms of the configuration of the multiple electrodes connected to the terminal switching unit **22**. The body fat measurement device **1**F includes electrodes HR, HL, BU**1**-BU**4**, BL**1**-BL**4**, and BA**1**-BA**4** as the multiple electrodes.

The aforementioned multiple electrodes include: hand electrodes HR and HL serving as upper limb electrodes placed in contact with surfaces of the upper limbs of the measurement subject; and back area electrodes BU**1**-BU**4**, BL**1**-BL**4**, and BA**1**-BA**4** placed in contact with the back area surface of the measurement subject. Of these, the hand electrodes HR and HL are placed in contact with the palms of the measurement subject's hands. As shown in FIGS. **15**A and **15**B, the back area electrodes BU**1**-BU**4**, BL**1**-BL**4**, and BA**1**-BA**4** are arranged in rows and placed in contact with the back area surface of the measurement subject. The hand electrodes HR and HL and the back area electrodes BU**1**-BU**4**, BL**1**-BL**4**, and BA**1**-BA**4** are all electrically connected to the terminal switching unit **22** described above.

Structure of Body Fat Measurement Device **1**F

FIG. **17** is a perspective view illustrating the body fat measurement device **1**F according to the present embodiment. Like the body fat measurement device **1**A according to the aforementioned first embodiment of the present invention, the body fat measurement device **1**F includes the fitting belt **100**C, which can surround the measurement subject's trunk area in a fitted state. However, unlike the body fat measurement device **1**A according to the aforementioned first embodiment of the present invention, the body fat measurement device **1**C does not include a platform-shaped lower limb unit onto which the measurement subject can step. With the body fat measurement device **1**C, the back area electrodes BA**1**-BA**4** are further provided on the electrode support member **120**.

To be more specific, the electrode support member **120**, which is configured of a curved plate, extends further downward than in the aforementioned first embodiment, and the back area electrodes BA**1**-BA**4** are provided on the front surface **121** of the area of the electrode support member **120** that has been extended. The back area electrodes BA**1**-BA**4** are provided so that all the electrodes are exposed on the front surface **121** of the electrode support member **120**. According to one or more embodiments of the present invention, the back area electrodes BA**1**-BA**4** protrude slightly from the front surface **121** of the electrode support member **120**. Through this, the back area electrodes BA**1**-BA**4** are, like the back area electrodes BU**1**-BU**4** and BL**1**-BL**4**, placed in contact with the back area surface of the measurement subject during the fitted state.

Even with the body fat measurement device **1**F, the same effects as the effects described above in the first embodiment of the present invention can be achieved. In addition, the measurement can be carried out in a seated position as well as a standing position, which makes it even easier to measure the body fat mass. With the body fat measurement device **1**F, there is no lower limb unit, and thus the device configuration can be simplified and the size of the device can be reduced.

Although body fat measurement devices according to several embodiments of the present invention have been described, it should be noted that the embodiments disclosed above are to be understood as being in all ways exemplary and in no way limiting.

Although the aforementioned first through fourth embodiments and the variations thereon describe examples in which the computation processes are configured so as to calculate the visceral fat cross-sectional area as the visceral fat mass and the subcutaneous fat cross-sectional area as the subcutaneous fat mass, the computation processes may be configured so that a different indicator than the visceral fat cross-sectional area, such as the visceral fat volume, visceral fat

weight, visceral fat level, or the like is calculated as the visceral fat mass, and a different indicator than the subcutaneous fat cross-sectional area, such as the subcutaneous fat volume, subcutaneous fat weight, subcutaneous fat level, or the like is calculated as the subcutaneous fat mass.

Although the aforementioned first through fourth embodiments and the variations thereon describe examples in which the configuration is such that both the visceral fat cross-sectional area and the subcutaneous fat cross-sectional area are calculated and displayed, the configuration may be such that only one of these indicators is displayed, or that only the subcutaneous fat cross-sectional area is calculated and displayed. Furthermore, the configuration may be such that various types of body composition information aside from the visceral fat cross-sectional area and the subcutaneous fat cross-sectional area (for example, the body fat mass, area-by-area fat mass, fat-free mass, and so on) are calculated and displayed.

While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

REFERENCE NUMERALS LIST

1A-**1**F body fat measurement device
10 control unit
11 computation processing unit
12 body impedance measurement unit
13 body shape information measurement unit
14 body composition information calculation unit
14*a* visceral fat mass calculation unit
14*b* subcutaneous fat mass calculation unit
21 constant current generation unit
22 terminal switching unit
23 potential difference detection unit
24 trunk area information detection unit
25 measurement subject information input unit
26 display unit
27 operating unit
28 power source unit
29 memory unit
100A-**100**D fitting belt
120 electrode support member
121 front surface
125A, **125**B electrode pad
126A, **126**B, **220**, **222** connection cable
140 belt portion
141, **147**, **363**, **366** opening
142 band-shaped member
144, **148**, **364** retaining member
145, **365** hook portion
146, **362** retained member
149 pin
151, **152** buckle portion
153, **154** light-transmissive window portion
200 lower limb unit
210 platform portion
211 top surface
221, **223**, **225**, **227** connector
300A-**300**D, **300**Aa, **300**Ab upper limb unit
310 right-hand grip portion
320 left-hand grip portion
340 main body unit
360 hanging member
360*a* projection
400 measurement subject
401 right foot
402 left foot
403 right hand
404 left hand
405 trunk area
AR**1**-AR**3**, D**1**, D**2** arrow
BA**1**-BA**4**, BL**1**-BL**4**, BU**1**-BU**4** back area electrode
FR, FL foot electrode
FL', FR' foot/hip electrode
HR, HL hand electrode
S**1**-S**13** step

The invention claimed is:

1. A body fat measurement device comprising:

a plurality of electrodes comprising back area electrodes for making contact with a surface of a back area that is an area on a back side of a trunk area of a measurement subject, and upper limb electrodes for making contact with a surface of upper limbs of the measurement subject;

a body impedance measurement unit for measuring a body impedance of the measurement subject's body using said plurality of electrodes;

a body composition information calculation unit that calculates a body fat mass based on said body impedance measured by said body impedance measurement unit;

a fitting belt for bringing said back area electrodes into contact with the surface of the back area of the measurement subject in a pressurized state by being tightened around the trunk area of the measurement subject; and

an upper limb unit comprising a gripping portion that can be gripped by a hand of the measurement subject, said upper limb electrodes being provided in said gripping portion,

wherein said upper limb unit can be attached to and detached from said fitting belt,

wherein the fitting belt comprises a buckle portion having a light-transmissive window portion,

wherein, when the fitting belt is tightened around the trunk area of the measurement subject, the fitting belt measures a circumferential length of the trunk area of the measurement subject,

wherein a surface of the light-transmissive window portion has a marker, and

wherein the light-transmissive window allows the measurement subject to visually check whether a position of a navel of the measurement subject matches a position of the marker.

2. The body fat measurement device according to claim **1**,

wherein said fitting belt comprises a first engagement member,

wherein said upper limb unit comprises a second engagement member that can engage with said first engagement member,

wherein said upper limb unit is attached to said fitting belt by said first engagement member entering an engaged state with said second engagement member, and

wherein said upper limb unit can be detached from said fitting belt by canceling said engaged state.

3. The body fat measurement device according to claim **2**,

wherein said first engagement member forms an opening by being attached to said fitting belt,

wherein said second engagement member has a predetermined length that enables said second engagement member to be inserted into said opening,

wherein said upper limb unit is attached to said fitting belt by said second engagement member being inserted into said opening, and

wherein said upper limb unit is detached from said fitting belt by said second engagement member being pulled out from said opening.

4. The body fat measurement device according to claim **2**, wherein the position at which said first engagement member is attached to said fitting belt can be moved along a lengthwise direction of said fitting belt.

5. The body fat measurement device according to claim **1**, wherein said upper limb unit further comprises a display unit that displays body composition information including said body fat mass calculated by said body composition information calculation unit.

6. The body fat measurement device according to claim **1**, wherein said upper limb unit further comprises an operating unit for accepting an instruction from the measurement subject.

7. The body fat measurement device according to claim **1**, wherein said plurality of electrodes further comprises lower limb electrodes for making contact with surfaces of lower limbs of the measurement subject, and

wherein the body fat measurement device further comprises: a lower limb unit for bringing said lower limb electrodes into contact with soles of feet of the measurement subject when the measurement subject steps onto the lower limb unit.

8. The body fat measurement device according to claim **7**, wherein said upper limb unit and said fitting belt are electrically connected to each other via a first wire, and

wherein one of said upper limb unit or said fitting belt is electrically connected to said lower limb unit via a second wire.

9. The body fat measurement device according to claim **7**, wherein connection cables that connect said upper limb unit, said fitting belt, and said lower limb unit can be connected to and disconnected from said upper limb unit, said fitting belt, and said lower limb unit.

10. The body fat measurement device according to claim **7**, wherein said lower limb unit comprises a body weight measurement unit for measuring a weight of the measurement subject.

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